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VOLUME 16 MARCH, 1942 NUMBER 2

MICROFAUNA OF THE GLEN DEAN LIMESTONE

H. N. CORYELL and GEORGE ROZANSKI
Columbia University, New York, New York

ABSTRACT—Microfossils have been found to be one of the useful factors in making correlation studies of the Chester formation. Two species of Foraminifera and 32 species and two varieties of Ostracoda constitute the authors' contribution to the microspecimens of the Glen Dean limestone, occurring in the upper part of the middle Chester of southern Illinois. The Ostracoda are classified in 10 families and 22 genera. Four of the genera, 29 of the species, and the two varieties are described as new. The two species of Foraminifera are new forms of the simple coiled types.

THE MATERIAL for this study was collected by Dr. Horace N. Coryell of Columbia University during the summer of 1937 from surface outcrops of the Glen Dean formation in Hardin county, Illinois. Three locations are represented (fig. 2) including

FIG. *1*—Outline map of Illinois, showing the location of Hardin County.

collections from the outcrop in the bluff along the northwest side of the road in the center of sec. 18, T. 12 S., R. 10 E., three-fourths mile southwest of Frailey's store; exposure in the stream bed five-eighths mile north of Karber's ridge at the intersection

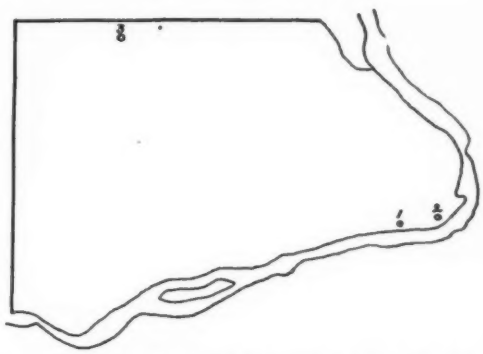


FIG. *2*—Outline of Hardin County, showing the principal collecting localities. 1, Bluff section; 2, Frailey's store; 3, near Karber's ridge.

of the stream and the road leading northward from the village; outcrop five-sixteenths mile southwest of Frailey's store just west of the intersection of Honey Creek and the road leading southwest from the store and showing in the bluff. In the section at the bluff, neither the top nor the bottom of the Glen Dean is exposed.

The following chronological list of the divisions of the Chester of Illinois shows the position of the Glen Dean formation:

Kinkaid limestone
Degonia sandstone
Clore limestone
Palestine sandstone
Menard limestone
Waltersburg sandstone
Vienna limestone
Tar Springs sandstone
Glen Dean limestone
Hardinsburg sandstone
Golconda limestone
Cypress sandstone
Paint Creek formation
Bethel sandstone
Renault limestone

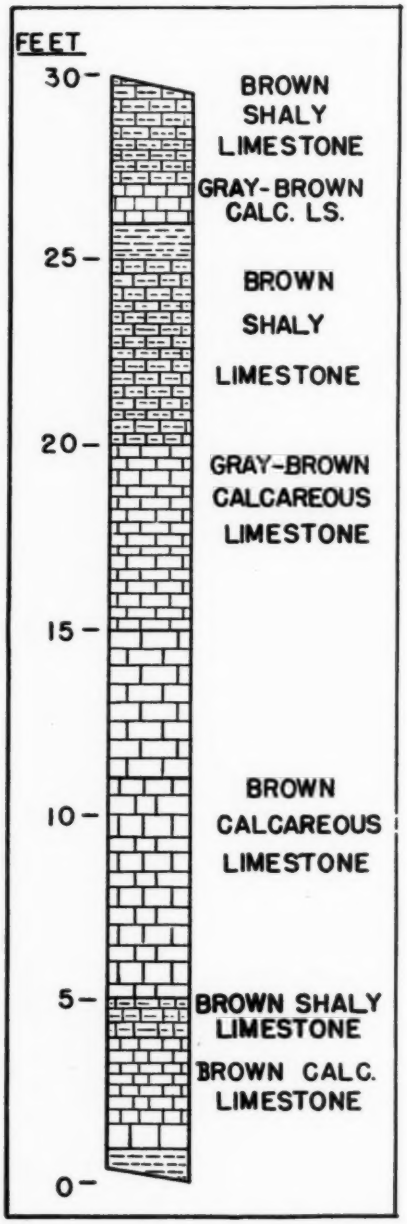


FIG. 3—Columnar section of the Glen Dean limestone at the Bluff section, Hardin County, Illinois.

The Glen Dean is often classified as the uppermost formation of the middle Chester. It was deposited in an embayment which extended westward as far as southeastern Missouri, northward to central Illinois, and southward through Kentucky and Tennessee. The name was first used by Butts (1917) in Breckinridge county, Kentucky. An equivalent formation was previously named Sloans Valley, from a locality in Pulaski county, Kentucky, by Brokaw in 1916. The name Glen Dean was retained by preference.

Stuart Weller stated that the average thickness of the Glen Dean was 60 feet. In the northwest corner of sec. 15, T. 11 S., R. 9 E., Weller assigned 10 feet of limestone overlain by 20 feet of shale and limestone, followed by 40 feet of limestone, to this formation, where the basal portion of the Tar Springs sandstone is exposed disconformably at the top of the section. The contact with the underlying Hardinsburg sandstone was not seen, but it is stated to grade conformably into the Glen Dean through a shale interval.

The Glen Dean formation is well exposed in the southeastern portion of Hardin County, in the Ohio River bluff one-half mile southwest of Frailey's store. From this point the outcrop extends northwestward in a narrow belt to the central faulted portion of the county; in the northwesterly portion of the county the outcrop forms a narrow band trending westerly into Pope County.

The formation varys in lithology from place to place, from dense to crystalline texture and gray to black color. Some beds are very pure carbonate alternating with thin layers of chocolate-brown chert. An oolitic limestone bed is widely distributed near the top of the formation.

SYSTEMATIC DESCRIPTIONS

PROTOZOA
Class RHIZOPODA
Order FORAMINIFERA
Family SPIRILLINIDAE
Subfamily SPIRILLININAE
Genus SPIRILLINA Ehrenberg, 1843
SPIRILLINA OBDUXA
Coryell and Rozanski, n. sp.
Plate 24, figure 27

Test minute, subcircular in lateral view, sides flattened curving evenly into the rounded peripheral margin; peripheral view sub-rectangular; composed of a proloculum, ovate in side view and a long undivided planispirally coiled second chamber consisting of about four coils enlarging very gradually. Maximum diameter, 0.32 mm.; minimum diameter, 0.28 mm., thickness, 0.10 mm.

Location.—Frailey's store section.

Holotype.—Columbia University micropaleontological collection.

Family ENDOTHYRIDAE
Subfamily ENDOTHYRINAE
Genus ENDOTHYRA Phillips, 1846
ENDOTHYRA BUNKERAE
Coryell and Rozanski, n. sp.
Plate 23, figure 1

Test free, subcircular, asymmetrical, forming a low sinistral spiral; 11 chambers in the last whorl, gradually increasing in size; sutures oblique, depressed but not markedly so, periphery broadly rounded, umbilicus prominent; surface finely granulose. Aperture not observed (last chamber broken). Diameter, 0.55 mm.

This species is distinctly smaller than the minimum size of the mature individual of *Endothyra baileyi* and possesses more chambers in the last whorl than the maximum included in that species.

Occurrence.—Upper Glen Dean; brown shaly limestone bed.

Holotype.—Columbia University micropaleontological collection.

OSTRACODA Latreille, 1806
Superfamily LEPERDITACEA Bassler and Kellett, 1934
Family LEPERDITELLIDAE Ulrich and Bassler, 1906
Genus PARAPARCHITES Ulrich and Bassler, 1906
PARAPARCHITES SAMUELI
Coryell and Rozanski, n. sp.
Plate 23, figure 2

Carapace subtriangular, length and height ratio 3.2 to 2.2; inequivalved, smooth. Greatest convexity of valves in antero-dorsal quarter, valves slope evenly to margins from the location of greatest convexity; dorsal margin is sigmoid, the left valve projecting above the hinge line; anterior border narrowly but smoothly rounded, point of greatest curvature above the midline; posterior broadly rounded, point of greatest curvature below the midline; ends merge evenly with the broadly rounded ventrum, midventer narrowly rounded; retral swing prominent; anterior cardinal angle obtuse, posterior angle indistinct; greatest height posterior to the median; hinge straight, more than half the length; the right valve overlaps the left ventrally and extends beyond the left on the ends; a raised tubercle is present in the antero-dorsal quarter of the left valve only. This species has been oriented with the eye tubercle anterior. Length, 0.78 mm., height, 0.54 mm., thickness, 0.35 mm.

Occurrence.—Bluff and Frailey's store sections.

Holotype.—Columbia University micropaleontological collection.

The species differs from *P. inornatus* (McCoy) and *P. nicklesi* (Ulrich), which have straight dorsa; it has a different length-height ratio from *P. robustus* Croneis and Gutke; it is smaller, lacks the post-dorsal truncation, and has a more sharply rounded venter.

PARAPARCHITES DISTORTUS
Coryell and Rozanski, n. sp.
Plate 23, figures 3, 4

Small carapace, subovate, length and height ratio 5 to 3, inequivalved, smooth; left valve umbonate; greatest convexity of right valve above the midline; right valve convexity bends sharply to meet the ventral margin, and slopes more gently to the end margins; the left valve convexity slopes regularly from the dorsal umbonation to the ventral border; the dorsum is regularly convex; anterior end narrowly rounded, poste-

rior more broadly curved and ventrum broadly convex; dorsal view ovate; retral swing not pronounced; cardinal angles indistinct; greatest length in the dorsal half, greatest height in posterior half, greatest thickness in dorsal half, hinge straight; umbonation of the left valve rises above the hinge line; the right valve overlaps the left along the ventral margin; overlap at ends narrow or lacking. Length, 0.6 mm.; height, 0.38 mm.; thickness, 0.21 mm.

Occurrence.—Frailey's store section.

Holotype.—Columbia University micropaleontological collection.

Genus ANTIPARAPARCHITES Coryell and Rogatz, 1932

ANTIPARAPARCHITES? OBLONGUS
Coryell and Rozanski, n. sp.
Plate 23, figures 5, 6

Carapace minute, suboblong, inequivalved, smooth; dorsum straight, ventrum slightly concave, anterior extremity is more extended near midheight; posterior margin broadly rounded and more extended in the ventral half; valves gently convex, bending abruptly to meet the ventral contact; cardinal angles distinct, posterior angulation more obtuse; greatest height posterior, greatest thickness varies from central to the anterior half; hinge straight, and long; right valve rises above the left dorsally and is overlapped along the free margins; overlap narrow where present. Dimensions of syntype (fig. 5): length, 0.43 mm.; height, 0.19 mm.; thickness, 0.1 mm.; cotype (fig. 6): length, 0.35 mm.; height, 0.17 mm.; thickness, 0.09 mm.

Occurrence.—Bluff and Frailey's store sections.

Syntypes.—Columbia University micropaleontological collection.

This species is assigned provisionally to *Antiparaparchites*. It differs in length-height ratio, in having a concave ventrum, and in its smaller size. It resembles *Antiparaparchites* in type of overlap.

Superfamily BEYRICHIACEA Ulrich and Bassler, 1923

Family KLOEDENELLIDAE Ulrich and Bassler, 1923

Genus NEOKLOEDENELLA Croneis and Funkhouser, 1939

NEOKLOEDENELLA? POLLAKAE
Coryell and Rozanski, n. sp.
Plate 23, figure 7

Carapace of medium size, subquadrate, smooth; valves apparently equal; valves moderately convex, increasing in convexity to meet the contact; dorsum straight; anterior more narrowly rounded than the posterior; ventrum broadly convex; dorsal view ovate; cardinal angles obtuse, more so in the anterior; greatest length approximately median, greatest height nearly central and thickness medially; hinge straight, longer than shell height, no articulatory processes observed. Length, 0.39 mm., height, 0.23 mm., thickness, 0.13 mm.

Occurrence.—Middle and lower Bluff section.

Holotype.—Columbia University micropaleontological collection.

NEOKLOEDENELLA OVULELLA
Coryell and Rozanski, n. sp.
Plate 23, figures 8–12

Carapace small, subquadrate, subequivalved; valves moderately convex increasing in convexity toward the contacts; dorsum straight; anterior margin evenly but narrowly rounded, posterior more broadly; ventrum straight or gently convex; dorsal view ovate; cardinal extremities rounded; greatest length approximately along the median line; greatest height in posterior half; hinge line short, depressed; indistinct processes are present at the ends of the hinge line in the right valve; the left valve is narrowly peripheral to the right at the ends but apparently does not overlap; the valves are thickened at the contact forming a narrow costa which runs the length of the ventrum; depending upon the greater or less development of the free marginal costae, the ventrum may be transversely relatively broad or narrow. The holotype may be a female form as it is thickest posteriorly. The position of greatest thickness is more centrally located in the paratypes. Measurements are as follows:

Occurrence.—Lower part of the Bluff and Frailey's store sections.

Holotype (fig. 8): Length, 0.45 mm., height, 0.25 mm., thickness, 0.18 mm.; *Paratype* (fig. 9). Length, 0.55 mm., height, 0.29 mm., thickness, 0.21 mm. *Paratype* (figs.

10–12): Length, 0.6 mm., height, 0.26 mm., thickness, 0.19 mm.

Holotype and paratypes.—Columbia University Micropaleontological Collection.

Family PRIMITIIDAE Ulrich and Bassler, 1923
Genus CORYELLINA Bradfield, 1935
CORYELLINA KURTI
Coryell and Rozanski, n. sp.
Plate 23, figures 13, 14

Carapace large, subquadrate, apparently equivalved; a vertical sulcus slightly anterior to the middle lies in the dorsal half; valves inflated posterior to the sulcus; the hinge line is depressed, straight, and is bordered by a flattened area that increases in width posteriorly; in lateral view the dorsum is straight with a slight convexity in the posterior half, where the inflated posterior projects slightly above the hingeline; the posterior margin is gently curved with greatest extremity dorsal; the anterior border is more narrowly rounded with farthest extremity median and swings backward to meet the broadly rounded ventrum; the dorsal view is cuneate, widest posteriorly; the cardinal angles are distinct, obtuse; the posterior angle is almost a right angle, the anterior greater; greatest height and thickness lies in the posterior half; a small process at the anterior cardinal angle of the right valve fits into a corresponding socket in the left valve; contact depressed dorsally and ventrally. Length, 0.6 mm., height, 0.35 mm., thickness, 0.4 mm.

Occurrence.—Upper part of Frailey's store section.

Holotype.—Columbia University micropaleontological collection.

Differs from *Coryellina capax* Bradfield in having a rounded posterior. This genus resembles *Primitia* in all but the inflation of the valves; *Plethobolbina* is different by having a crest on the anterior lobe.

CORYELLINA INDISTINCTA
Coryell and Rozanski, n. sp.
Plate 23, figure 15

Carapace medium size, subrhomboid, equivalved except at cardinal angles; greatest length about median; greatest height in anterior half; greatest thickness central, below mid-height; posterior cardinal angle almost a right angle, anterior indistinct, obtuse; hinge straight, long; right valve overlaps the left at the anterior and posterior cardinal angles; overlap at the anterior angle is strong, at the posterior, slight; valves are otherwise equal. Dorsum straight; anterior broadly rounded, curving gently into the slightly convex ventrum; posterior broadly curved; depression of the ventral commissure extends only a short way on to the end; valve surface is convex, more sharply near the margins than elsewhere; dorsal view ovate; end view subovate.

A sulcus is present slightly anterior to the center, extending from the dorsum to above the median line; it is marked anteriorly by a small ill-defined node rising above the convexity of the valve. Length, 0.71 mm., height, 0.37 mm., thickness, 0.28 mm.

Occurrence.—Lower part of Bluff and Frailey's store section.

Holotype.—Columbia University micropaleontological collection.

Genus PERPRIMITIA Croneis and Gale, 1939
PERPRIMITIA FRAILEYI
Coryell and Rozanski, n. sp.
Plate 23, figure 16

Carapace medium size, suboblong, right valve larger, overlapping the left valve along the free margins, most ventrally; hinge line straight, depressed posteriorly and crested anteriorly; dorsum concave; anterior margin broadly rounded, joining evenly into the broadly curved ventrum; greatest extremity of the ends approximately median; anterior to the vertical, dorso-lateral, median sinus is a small rounded prominence, which rises steeply from the sinus and then slopes gently anteriorly; dorso-anterior margin compressed; posterior half of valve highly convex, sloping steeply to the dorsal margin. A small spine, extending upward and backward, is present on the crest of the posterodorsal flattened area. Maximum thickness, near the center of the posterior lobe that is separated by a shallow sulcus from the ventral swelling. Cardinal angles rounded; greatest height in anterior half.

The strong posterior inflation of this species may be a dimorphic character. Length,

0.56 mm., height, 0.34., thickness, 0.28 mm.

Occurrence.—Lower Bluff section.

Holotype.—Columbia University micropaleontological collection.

Differs from *P. funkhouseri* in having a concave dorsum, and lack of cardinal overlap; from *P. spinosa* in the position of the spine; from *P. robusta* in having a distinct node anterior to the sulcus.

Genus CARBOPRIMITIA Croneis and Funkhouser, 1939

CARBOPRIMITIA MINUTA
Coryell and Rozanski, n. sp.
Plate 23, figure 19

Carapace small to medium, elongate; hingement simple, straight, depressed; cardinal angles obtuse; posterior narrowly curved above the median line and the anterior narrowly curved below the median line; right valve overlaps the left along the free contact, greatest along the ventral margin; a vertically elongated pit and anteriorly adjacent node is present in the anterodorsal quarter. In the posterior half the valves are inflated, the bulging rising distinctly above the hinge line near the middle of the posterior half of the hingement. A conspicuous marginal fold parallels the entire anterior border. Length, 0.87 mm., height, 0.54 mm., thickness, 0.44 mm.

Occurrence.—Upper part of the Bluff section.

Holotype.—Columbia University micropaleontological collection.

The small size, dimension ratio, and relatively greater posterior gibbosity distinguishes this form from other described species.

CARBOPRIMITIA ROUNDYI
Coryell and Rozanski, n. sp.
Plate 23, figures 20, 21

Carapace medium sized, subovate, right valve larger, overlapping the left on the free margin; greatest overlap ventral; dorsum slightly convex; anterior broadly rounded with a forward swing; posterior more narrowly rounded; posterior extremity above midheight; ventrum evenly convex, curving more sharply anteriorly than posteriorly; dorsal view subcuneate, widest posteriorly; greatest height in anterior half; hinge straight, depressed, with a distinct anterior cardinal process of the right valve overlapping the left, and a less distinctly developed angular overlap in the posterior; the left valve is flattened near the anterior margin, flattening disappearing ventrally; narrowly flattened posteriorly; the sulcus interrupts the even central convexity of the valves; the right sulcus is more distinctive than that of the left valve. Length, 0.70 mm., height, 0.42 mm., thickness, 0.24 mm.

Occurrence.—Bluff section and upper Frailey's store section.

Holotype.—Columbia University micropaleontological collection.

This species is named in honor of P. V. Roundy. It differs from *C. simulans* Croneis and Thurman and *C. depressa* Croneis and Funkhouser in having a straight dorsal margin, and from *C. rotunda* Croneis and Funkhouser in position of greatest thickness and the unequal development of sulci; *C. rotunda tumida* has a stronger offset at the posterior end of the hinge.

Family GLYPTOPLEURIDAE Girty, 1910

Genus GLYPTOPLEURA Girty, 1910

The genus *Glyptopleura* is represented in the Glen Dean by a few species but none were sufficiently well preserved to allow specific determination.

Genus GLYPTOPLEUROIDES Croneis and Gale, 1939

GLYPTOPLEUROIDES RETICULATUS
Coryell and Rozanski, n. sp.
Plate 23, figures 22, 23

Carapace small, subrhomboidal; dorsum straight; anterior with a ventral forward swing; posterior half of ventrum straight, curving abruptly into posterior end; greatest length median, greatest height in the anterior half; greatest thickness posterior; hinge straight, long, depressed; a small process is present at the anterior cardinal angle of the right valve, which overlaps on the left valve; valve contacts at the posterior cardinal angle even; valve contacts depressed along the free margins.

Valves are rimmed by a broad ridge that appears multiple near the posterior ventral margin, and indistinctly double along the anterior end; the posterior margin is parallelled by a double ridge that merges into the

outer ridge of the ventral margin; short grooves ornament the surface in the anterodorsal and central dorsal area. In the grooves, are quite distinct pits, and in places the grooves appear to be formed by the coalescing of these pits; the general pattern of the grooves is the same on both valves; on the right side it is more distinct and somewhat more irregular. The ventral ridge is finely but distinctly ornamented by reticulations elongated parallel to the margin. The ribs of the left valve are more distinctly reticulated at irregular intervals than the right valve. Length, 0.59 mm., height, 0.32 mm., thickness, 0.23 mm.

Occurrence.—Lower part of the Bluff section.

Holotype.—Columbia University micropaleontological collection.

Differs from previously described species of this genus in the disposition of ornamentation and the presence of reticulation.

Genus IDIOMORPHINA Croneis and Gale, 1939

IDIOMORPHINA CHADWICKI
Coryell and Rozanski, n. sp.
Plate 23, figure 24

Carapace small, suboblong, with straight depressed hinge line; anterior broadly rounded, posterior narrowly rounded; anterior extremity below mid-height; posterior extremity slightly above mid-height; mid-ventrum straight; anterior cardinal angle distinct, obtuse; posterior cardinal extremity rounded; greatest height anterior to the center; greatest thickness in posterior half. A deep sulcus is present anterodorsal of the center; posterior to the sulcus rises a subglobose swelling which slopes gently to the sulcus and abruptly to the posterior valve contact; a lobe occurs anterior to the median sulcus that continues ventrally as a broad ridge to the mid-height where it turns sharply posteriorly and extends upon the posterior swelling. Separating this lobe from the free marginal convexity is a narrow well-defined sulcus which broadens ventrally and is very narrow around the posterior lobe; an anterior ventral costa occurs near the anterior ventral margin; the dorsal margins are marked by a raised thickening. Length, 0.7 mm., height, 0.41 mm.

Occurrence.—Base of the Bluff section.

Holotype.—Columbia University micropaleontological collection.

This form named in honor of George H. Chadwick, differs from *I. ornata* Croneis and Gale in having a straight ventrum and a wide median sinus trending dorsoventrally.

IDIOMORPHINA MALKINAE
Coryell and Rozanski, n. sp.
Plate 23, figure 25

Carapace medium sized, suboblong, anterior broadly rounded, posterior extremity above midheight; midventrum almost straight; cardinal angles distinct; greatest height in anterior half, but varying little throughout the midsection; greatest thickness posteroventral of center; hinge straight. The dorsal margins of both valves are thickened forming a marginal costa; free margin of right valve is thickened; a prominent sulcus is present dorsoanterior to the center and extends anteroventrally as a narrow groove; it also connects indistinctly with the shallow hooked sinus that lies both dorsal and ventral to the prominent median longitudinal ridge; a flattened lobe lies between the anterior and median sulcus; it is drawn out anteroventrally as a ridge which bends abruptly to the posterior, joining the median longitudinal ridge; in front of the anterior sulcus is a broad ridge split by a shallow depression; this ridge subparallels the anterior and ventral margins, the depression becoming a distinct sulcus ventrally and dividing the ridge into two narrow subparallel costae; postventrally this sulcus disappears and the marginal costae unite, trending dorsally as a narrow costa which outlines the anterior margin of the posterior swelling; at the anteroventral angle the ventral costa of the anterior lobe bifurcates, the costa thus produced paralleling the ventral margin beyond the mid-line before dying out. Length, 0.93 mm., height, 0.45 mm., thickness, 0.27 mm.

Occurrence.—Lower Bluff and Frailey's store sections.

Holotype.—Columbia University micropaleontological collection.

Differs from *I. insignis* Croneis and Gale in outline and disposition of ornamentation.

Genus SANSABELLA Roundy, 1926

SANSABELLA SIMPLEX

Coryell and Rozanski, n. sp.

Plate 23, figures 17, 18

Carapace small, subquadrate, inequivalved, smooth; greatest length median, greatest height anterior, greatest thickness anterior to the center; cardinal angles distinct, subequal; hinge straight, depressed. The right valve overlaps the left at the cardinal angles and on the free margins. Dorsum straight; ventral margin broadly convex; the anterior margin is broadly rounded, posterior more narrowly curved; valves evenly convex.

The orientation is here reversed from Roundy's, so that the highest portion of the shell is anterior and the thickest posterior. This makes the right valve the larger. Length, 0.52 mm., height, 0.28 mm., thickness, 0.21 mm.

Occurrence.—Bluff section and the upper part of the Frailey's store section.

Holotype.—Columbia University micropaleontological collection.

This species differs from *S. inflata* Geis and *S. harrisi* Croneis and Funkhouser in being evenly convex and in having no pit. *S. reversa* Morey has a more evenly rounded venter and a convex dorsum.

Family QUASILLITIDAE Coryell and Malkin, 1936

Genus PARGRAPHYLUS

Coryell and Rozanski, n. gen.

Carapace small, subrhomboidal; dorsum

EXPLANATION OF PLATE 23

FIGS. *1*—*Endothyra bunkerae* Coryell and Rozanski, n. sp. Side view, ×40. (p. 139)

2—*Paraparchites samueli* Coryell and Rozanski, n. sp. Left view showing tubercle, ×35. (p. 139)

3, 4—*Paraparchites distortus* Coryell and Rozanski, n. sp. *3*, Right valve of holotype; *4*, dorsal view of a paratype, anterior end up, ×30. (p. 139)

5, 6—*Antiparaparchites, oblongus* Coryell and Rozanski, n. sp. *5*, Left valve of syntype showing peripheral dorsal margin of right valve; *6*, right valve of syntype showing overlap of left valve on free margins. Customary orientation. ×55. (p. 140)

7—*Neokloedenella? pollakae* Coryell and Rozanski, n. sp. Left valve of holotype showing characteristic outline. ×60. (p. 140)

8–12—*Neokloedenella ovulella* Coryell and Rozanski, n. sp. *8*, Right valve of holotype; note narrower anterior end. This is a well preserved and polished specimen which falsely appears exfoliated due to the uneven coating of ammonium chloride, ×50; *9*, ventral view of paratype A, note the contact costae; ×50; *10*, dorsal view of paratype B, posterior cardinal angle broken, ×45; *11*, left view of paratype B, ×45; *12*, ventral view of same, left valve down, note the marginal costae, ×60. (p. 140)

13, 14—*Coryellina kurti* Coryell and Rozanski, n. sp. *13*, Right view of holotype, ×40; *14*, dorsal view of holotype, anterior end upward, showing cardinal process, ×55. (p. 141)

15—*Coryellina indistincta* Coryell and Rozanski, n. sp. Left view of holotype, ×45. (p. 141)

16—*Perprimitia fraileyi* Coryell and Rozanski, n. sp. Right view of holotype, anterior margin broken. (p. 141)

17, 18—*Sansabella simplex* Coryell and Rozanski, n. sp. *17*, Left view of holotype, ×55; *18*, dorsal view of paratype, right valve upward, posterior slightly crushed, ×50. (p. 144)

19—*Carboprimitia minuta* Coryell and Rozanski, n. sp. Left view of hypotype showing post) dorsal projection of right valve, ×30. (p. 142)

20, 21—*Carboprimitia roundyi* Coryell and Rozanski, n. sp. *20*, Left view of holotype, ×55; *21*, dorsal view anterior upward. (p. 142)

22, 23—*Glyptopleuroides reticulatus* Coryell and Rozanski, n. sp. *22*, Left view of holotype, ×50; *23*, ventral view of holotype showing reticulated border, anterior to the left. (p. 142)

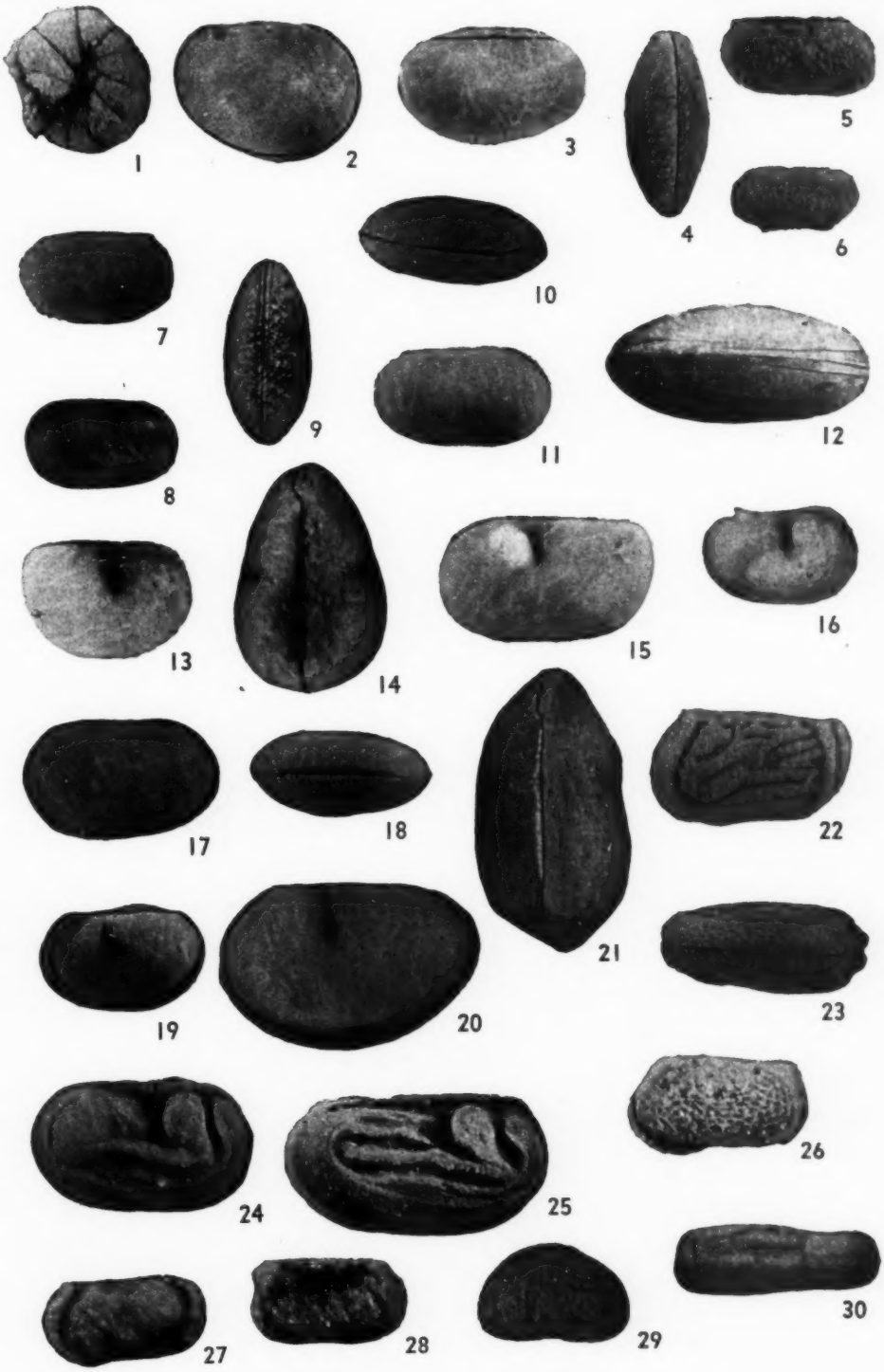
24—*Idiomorphina chadwicki* Coryell and Rozanski, n. sp. Right view of a paratype, ×45. (p. 143)

25—*Idiomorphina malkinae* Coryell and Rozanski, n. sp. Right view of the holotype, anterior cardinal angle broken, ×40. (p. 143)

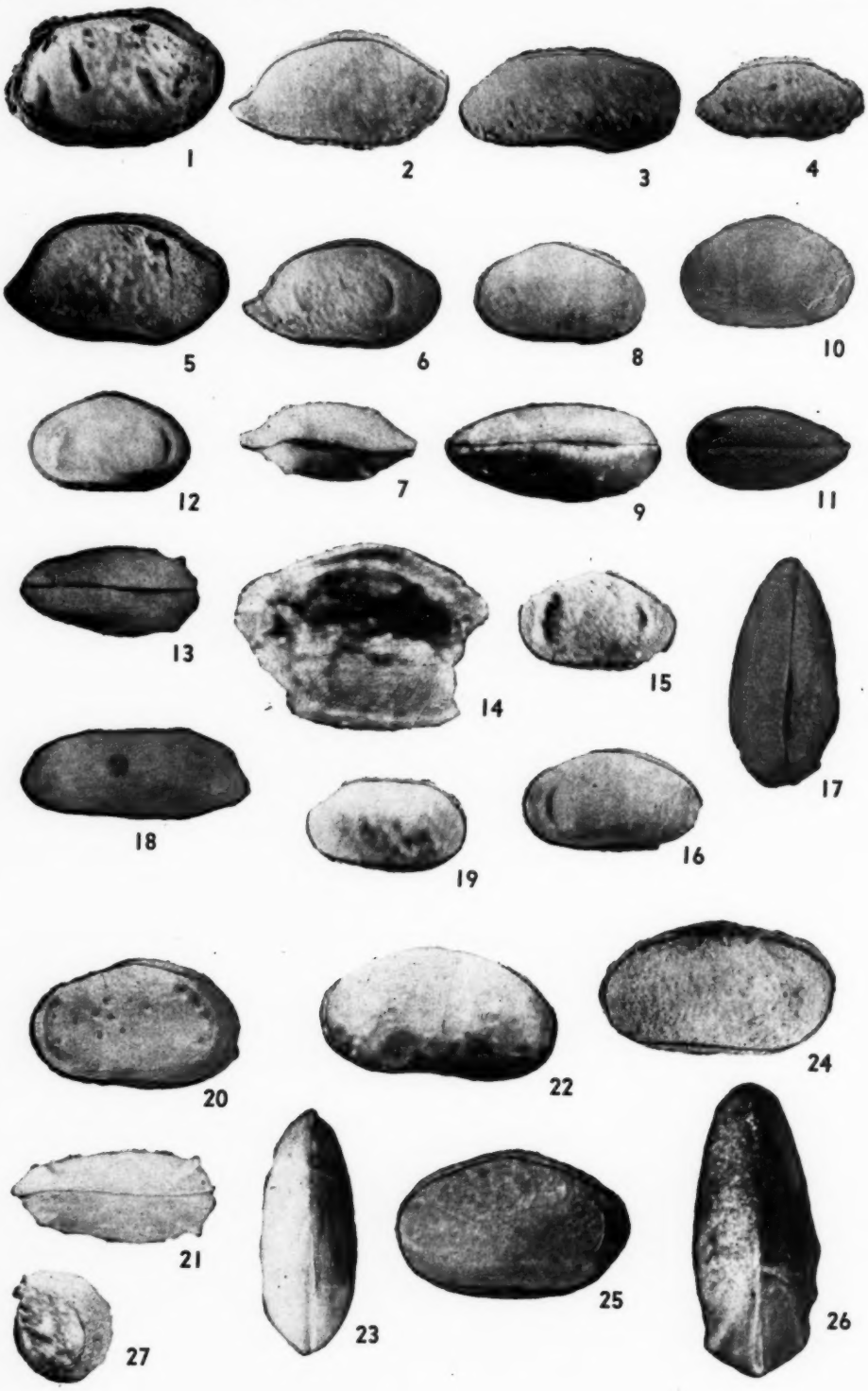
26, 30—*Paragraphylus reticulatus* Coryell and Rozanski, n. sp. *26*, Left view of the genoholotype showing the ventral overlap of the right valve, broken in the center, ×65; *30*, ventral view of genoholotype, posterior to the left, showing marginal costae and the mold of the internal band impressed on the interior, seen where the external shell has been broken away, ×75. (p. 145)

27, 28—*Hardinia concava* Coryell and Rozanski, n. sp. *27*, Left view of genoholotype, ×70; *28*, right view of crushed paratype showing grooved hinge in left valve, specimen slightly tilted when photographed. (p. 146)

29—*Bythocypris croneisi* Coryell and Rozanski, n. sp. Right view, posterior margin broken, ×25. (p. 146)



Coryell and Rozanski, Mississippian Microfossils



Coryell and Rozanski, Mississippian Microfossils

straight to gently convex, ventrum subparallel to the dorsal margin; dorsal view subcuneiform; cardinal angles distinct; greatest thickness in posterior half; right valve is larger ventrally and is rabbeted to receive the edge of the left; surface finely reticulate; a small spine is present posteroventrally, and the ends are marked by low broad keels.

This genus differs from *Janetina* Coryell and Malkin in its reticulate ornamentation and from *Graphiodactylus* Roth by the presence of a frill.

PARAGRAPHYLUS RETICULATUS
Coryell and Rozanski, n. sp.
Plate 23, figures 26, 30

Carapace minute, subquadrate, inequivalved; dorsum very slightly convex, bending abruptly into the nearly straight ventrum; cardinal angles distinct and obtuse; dorsum and ventrum approximately parallel; greatest length approximately at mid-height; thickest in posterior half; hinge straight, long; the left valve projects above the right dorsally; ventrally the left valve is overlapped by the right and fits into the rabbeted edge of the latter; the surface is finely reticulate, with the border reticulations arranged parallel to the margin; a smooth band is present on the entire margin, widest at the ends. Along the free margin of the shell the position of this band is indistinctly marked by two low, narrow, parallel costae, one at the very edge of the valve, the other near the contact. Length, 0.41 mm., height, 0.2 mm., thickness, 0.08 mm.

Occurrence.—Lower part of the Bluff section.

EXPLANATION OF PLATE 24

FIGS. *1*—*Bairdia seminalis* Knight, Hypotype, left view of the badly weathered adult, ×25. (p. 146)
2—*Bairdia golcondensis* Croneis and Gale, Right view of a hypotype. The extremities of both acuminations of the left valve have been chipped, ×60. (p. 146)
3—*Bairdia perplexa* Coryell and Rozanski, n. sp. Right view of holotype, posterior extremity broken, ×45. (p. 147)
4—*Bairdia sohni* Coryell and Rozanski, n. sp. Right view of holotype, ends s'ightly worn, ×30. (p. 147)
5—*Bairdia cooperi* Croneis and Gale, Right view of hypotype, ×25. (p. 147)
6, 7—*Bairdiolites fovealis* Coryell and Rozanski, n. sp. *6*, Right view of holotype, central pitted area indistinctly shown, ×50; *7*, dorsal view of a paratype, left valve upward, showing depressed mid-dorsal area. (p. 147)
8, 9—*Healdiacypris subtriangularis* Coryell and Rozanski, n. sp. *8*, Right view of holotype, ×55; *9*, dorsal view of holotype, anterior to the left, ×70. (p. 147)
10, 11—*Healdiacypris subtriangularis tuberculatus* Coryell and Rozanski, n. var. *10*, Left view of holotype, ×60; *11*, ventral view showing tubercle on post-ventral quarter of right valve. (p. 148)
12–14—*Healdioides diversus* Coryell and Rozanski, n. sp. *12*, Right view of genoholotype, ×50; *13*, dorsal view of a paratype showing depressed posterior contact, ×50; *14*, inside of a broken left valve showing grooved hingement, ×110. (p. 148)
15—*Healdioides diversus spinosus* Coryell and Rozanski, n. var. Right view of holotype, overlapping edge of left valve broken along anterior margin, ×50. (p. 149)
16, 17—*Healdioides bradfieldi* Coryell and Rozanski, n. sp. *16*, Right view of holotype, overlapping edge of left valve broken anteroventrally, ×55; *17*, dorsal view of holotype, anterior end upward, ×65. (p. 149)
18—*Microcheilinella acuminata* Coryell and Rozanski, n. sp. Right valve of holotype, ×50. (p. 149)
19—*Microcheilinella ovata* Coryell and Rozanski, n. sp. Right view of holotype; the posterodorsal slope has been flattened and falsely appears concave, ×55. (p. 149)
20, 21—*Seminolites impressus* Coryell and Rozanski, n. sp. *20*, Right valve of holotype, overlapping edge of left valve broken along the anterior margin, ×75; *21*, dorsal view, anterior to the left. (p. 148)
22, 23—*Haworthina salmonae* Coryell and Rozanski, n. sp. *22*, Right view of holotype, the concavity of the ventral margin has been emphasized by crushing, ×70; *23*, dorsal view of the holotype, anterior end upward. (p. 150)
24—*Cavellina croneisi* Coryell and Rozanski, n. sp. Left valve of holotype showing the faint reticulation of the anterior portion of the carapace, ×30. (p. 149)
25, 26—*Cavellinella moreyi* Coryell and Rozanski, n. sp. *25*, Left view of holotype showing pitted area anterior to the ridge; ×50; *26*, dorsal view of a paratype, anterior end upward, ×65. (p. 150)
27—*Spirillina obduxa* Coryell and Rozanski, n. sp. Side view, ×55. (p. 139)

Holotype.—Columbia University micropaleontological collection.

Paragraphylus reticulatus is herein designated as the genotype of *Paragraphylus* Coryell and Rozanski, n. gen.

Family YOUNGIELLIDAE Kellett, 1933
Genus HARDINIA
Coryell and Rozanski, n. gen.

Carapace small, suboblong, equivalved; valves compressed to broadly convex; dorsum straight or slightly curved; cardinal angles distinct; greatest height anterior; greatest thickness in posterior half; hinge straight, articulation by a groove in the left valve and a tongue in the right; ends bordered by a broad ridge which dies out ventrally.

HARDINIA CONCAVA
Coryell and Rozanski, n. sp.
Plate 23, figures 27, 28

Carapace minute, suboblong, equivalved; dorsum is approximately straight; anterior broadly rounded; posterior evenly rounded, curving narrowly into the concave ventrum; cardinal angles distinct and obtuse; greatest length about median, greatest height anterior; greatest thickness in posterior half; hinge straight, articulation by means of a groove in the left valve and a corresponding tongue in the right valve; ventral margin narrowly thickened along contact line. At each end of the valve a narrow sulcus sets off a broad ridge, which merges into the ventral margin of the valve. Carapace compressed along the dorsal margin; an undefined subcentral depression is indicated on some specimens.

Only one specimen was found which showed the internal structure of the hinge. This is a crushed specimen and is figured. Length, 0.35 mm., height, 0.16 mm., thickness, 0.11 mm.

Occurrence.—Lower half of the Bluff section.

Holotype.—Columbia University micropaleontological collection.

This species may be differentiated from other forms of this family by its general outline, ornamentation, and hinge structure. The orientation is reversed from *Moorites.*

Hardina concava is herein designated as the genotype of *Hardinia* Coryell and Rozanski, n. gen.

Superfamily CYPRIDACEA Dana, 1852
Family BAIRDIIDAE Sars, 1887
Genus BYTHOCYPRIS Brady, 1880
BYTHOCYPRIS CRONEISI
Coryell and Rozanski, n. sp.
Plate 23, figure 29

The Glen Dean specimen differs distinctly from the Clore type in a number of points which are worthy of note. In lateral outline, the Glen Dean form has the line of greatest length distinctly nearer the ventral border when compared to the Clore form; the former is much larger, with the dorsal half thicker than the ventral and the maximum thickness about central; overlap is strongest dorsally. Length, 0.9 mm., height, 0.53 mm., thickness, 0.38 mm.

Occurrence.—Bluff and Frailey's store sections.

Holotype.—Columbia University micropaleontological collection.

Genus BAIRDIA McCoy, 1844
BAIRDIA SEMINALIS Knight
Plate 24, figure 1

Bairdia seminalis KNIGHT *1928*, Jour. Paleontology, vol. 2, p. 320, pl. 43, figures 2 a-d.

This adult, a weathered specimen, has been identified provisionally as Knight's form. Length, 1.26 mm., height, 0.87 mm., thickness, 0.51 mm.

Occurrence.—Bluff section.

Hypotype.—Columbia University micropaleontological collection.

BAIRDIA GOLCONDENSIS Croneis and Gale
Plate 24, figure 2

Bairdia golcondensis CRONEIS and GALE *1938*, Denison Univ. Bull., vol. 38, no. 10.
Bairdia golcondensis, CRONEIS and GALE, *1938*, Jour. Sci. Lab., vol. 33, art. 5, pp. 286–287, pl. 6, fig. 26–27.
Bairdia golcondensis, CRONEIS and GUTKE, *1939*, Denison Univ. Bull., vol. 39, no. 3.
Bairdia golcondensis, CRONEIS and GUTKE, *1939*. Jour. Sci. Lab., vol. 34, art. 3, p. 58; pl. 2, f. 23.

This species resembles the type in outline and length-height ratio. Length, 0.57 mm., height, 0.28 mm., thickness, 0.18 mm.

Occurrence.—Bluff and Frailey's store sections.

Hypotype.—Columbia University micropaleontological collection.

BAIRDIA COOPERI Croneis and Gale
Plate 24, figure 5

Bairdia cooperi CRONEIS and GALE *1938*, Denison Univ. Bull., vol. 38, no. 10.
Bairdia cooperi CRONEIS and GALE, *1938*, Jour. Sci. Lab., vol. 33, art. 5, p. 257, pl. 6, fig. 11–12.

This specimen agrees with the type description in almost all respects. The posterior beak of the Glen Dean form is slightly more pronounced but the length-height ratio and general outline are the same. Length, 1.30 mm., height, 0.70 mm., thickness, 0.50 mm.

Occurrence.—Bluff and Frailey's store sections.

Hypotype.—Columbia University micropaleontological collection.

BAIRDIA PERPLEXA
Coryell and Rozanski, n. sp.
Plate 24, figure 3

Carapace of medium size, elongated, length more than twice the height, surface smooth; dorsum broadly curved; anterior dorsal slope inclined gently anteriorly and rounding abruptly into the anterior margin; posterior slope steep; posterior extremity below midheight, narrowly rounded into the concave ventrum; dorsum and ventrum subparallel; greatest height anterior of center; greatest thickness approximately central. Left valve overlaps right along entire dorsal and ventral margins, strongest midventrally and along the dorsal arch. Length, 0.71 mm., height, 0.28 mm., thickness, 0.14 mm.

Occurrence.—Bluff and Frailey's store sections.

Holotype.—Columbia University micropaleontological collection.

This species differs from *B. hoxbarensis* Kellett (Roth, 1929, p. 131) not Harlton, in being smaller, more broadly rounded anteriorly and having the posterior extremity well below the midheight.

BAIRDIA SOHNI
Coryell and Rozanski, n. sp.
Plate 24, figure 4

Carapace large, subreniform, inequivalved; valves flatly convex centrally and flattened at the ends; dorsal margin broadly convex along middle, becoming concave at each extremity slope; anterior extension above midheight and narrowly rounded with a backward swing to the concave ventrum; posterior angle is slightly below midheight; greatest height approximately central; left valve overlaps right, overlap greatest middorsally and midventrally, narrowing towards the ends. Length, 0.84 mm., height, 0.33 mm., thickness, 0.19 mm.

Occurrence.—Upper part of the Frailey's store section.

Holotype.—Columbia University micropaleontological collection.

This species lacks the strongly curved ventral overlap of *B. galei.*

Genus BAIRDIOLITES Croneis and Gale, 1939
BAIRDIOLITES FOVEALIS
Coryell and Rozanski, n. sp.
Plate 24, figures 6, 7

The Glen Dean form somewhat resembles *B. cresentis* from the Golconda formation in dimensions and lateral outline. It differs in being more rounded dorsally and having somewhat steeper postdorsal and posterior slopes; the posterior beak is more distinct and somewhat higher. The left valve is larger all around, projecting beyond the right along the beak rather than actually overlapping it.

Adult specimens and young moults are pitted in the flattened area between the ridges. Length, 0.8 mm., height, 0.4 mm., thickness, 0.3 mm.

Occurrence.—Bluff and Frailey's store section.

Holotype.—Columbia University micropaleontological collection.

Family HEALDIIDAE Harlton, 1933
Genus HEALIDACYPRIS Bradfield, 1935
HEALDIACYPRIS SUBTRIANGULARIS
Coryell and Rozanski, n. sp.
Plate 24, figures 8, 9

Carapace small, smooth, subtriangular, left valve larger; length about twice height; greatest length only slightly below the median line; greatest thickness slightly postcentral. Dorsum arched, highest just posterior of the middle, with the posterior slope slightly steeper than the anterior; end margins quite regularly curved; ventral border straight; overlap of left valve over right narrow and entire except along the postal

slope and a part of the anterior margin. Length, 0.47 mm., height, 0.25 mm., thickness, 0.16 mm.

Occurrence.—Lower half of the Bluff section and Frailey's store section.

Holotype.—Columbia University micropaleontological collection.

HEALDIACYPRIS SUBTRIANGULARIS var. TUBERCULATUS
Coryell and Rozanski, n. var.
Plate 24, figures 10, 11

This variety differs from *H. subtriangularis* by being more highly arched dorsally and possessing a small tubercle on the post-ventral angle of the right valve. No specimens were observed that showed any indication of a similar tubercle on the left valve. Length, 0.41 mm., height, 0.23 mm., thickness, 0.16 mm.

Occurrence.—Lower half of the Bluff section and the Frailey's store section.

Holotype.—Columbia University micropaleontological collection.

Genus SEMINOLITES Coryell, 1928
SEMINOLITES IMPRESSUS
Coryell and Rozanski, n. sp.
Plate 24, figures 20, 21

Carapace small, subtriangular, inequi valved, longer than wide; greatest length about median, greatest height anterior to the center; greatest thickness in posterior half. Hinge on postero-dorsal slope is straight and depressed; dorsum is strongly arched, antero-dorsal slope convex, post-dorsal slope straight to concave; ventrum slightly convex, anterior broadly rounded, posterior more narrowly rounded; left valve overlaps right along the entire margin except along the postal slope. Valves moderately convex, surface of valve marked by curved ridges, one near each end, posterior ridge stronger than anterior; concave slopes of ridges steep, outward slope of anterior ridge gentle and continuous with the curvature of the valve to the contact; the concave sides of the ridges are marked by deep, round, distinct pits. Several pits occur scattered irregularly but mainly over the posterior half of the valve. Length, 0.40 mm., height, 0.20 mm., thickness, 0.15 mm.

Occurrence.—Basal Bluff section.

Holotype.—Columbia University micropaleontological collection.

This species differs from the typical *Seminolites* in having a depressed hinge on the posterior slope.

Genus HEALDIOIDES
Coryell and Rozanski, n. gen.

Small to medium sized ostracoda; subovate in outline with an arched dorsal margin; left valve is larger and overlaps the right except on the postal slope; ends are rounded; greatest thickness is in the posterior half. Hingement consists of a tongue in the right valve and a groove in the left. The carapace is ornamented by a curved ridge and an inner adjacent depression, located near one or both ends and parallel to the margin. The ridges may end in spines. Ornamentation of the left valve is commonly weaker than the right.

Healdioides differs from *Healdia* Roundy in the type of ornamentation; from *Eucraterallina* Wilson in not having complete overlap all around; and from *Rothella* Wilson, which has no overlap dorsally.

HEALDIOIDES DIVERSUS
Coryell and Rozanski, n. sp.
Plate 24, figures 12–14

Carapace small, subovate, inequivalved; greatest length slightly below the median line; greatest height and thickness approximately central. Steep posterior slope interrupted by a ridge; hinge on post-dorsal margin, depressed; hingement by means of a tongue and groove arrangement. Dorsum arched with marginal slopes subequal, straight to gently convex; end margins subequal, greatest curvature median. Left valve overlaps the right except on the antero-dorsal angle and the postero-dorsal half. Valve marked by a posterior and anterior curved ridge, approximately paralleling the end borders; an ill-defined depression occurs within each curved ridge. Length, 0.5 mm., height, 0.25 mm., thickness, 0.18 mm.

Occurrence.—Bluff and Frailey's store sections.

Holotype.—Columbia University micropaleontological collection.

Healdioides diversus is herein designated the genotype of *Healdioides* Coryell and Rozanski, n. gen.

HEALDIOIDES DIVERSUS
var. SPINOSUS
Coryell and Rozanski, n. var.
Plate 24, figure 15

This species differs from *H. diversus* in the stronger development of the posterior ridge. The ridge is very high and narrow and ends in small backward pointing spines. Length, 0.5 mm., height, 0.28 mm., thickness, 0.17 mm.

Occurrence.—Lower Bluff and Frailey's store sections.

Holotype.—Columbia University micropaleontological collection.

HEALDIOIDES BRADFIELDI
Coryell and Rozanski, n. sp.
Plate 24, figures 16, 17

Carapace small, subovate, inequivalved; greatest length and height approximately median, greatest thickness in posterior half; posterior half of dorsum channeled. Dorsum broadly arched, anterior slope broadly rounded, posterior slope is approximately a straight line with depressed contact; end margins rounded, subequal; ventrum straight. The left valve overlaps the right on all but the post-dorsal half. A ridge, convex outward is present near the posterior margin of the carapace, bordered by a narrow sulcus on the concave side. The valve slopes steeply from the ridge to the posterior contact. Length, 0.5 mm., height, 0.25 mm., thickness, 0.19 mm.

Occurrence.—Bluff and Frailey's store sections.

Holotype.—Columbia University micropaleontological collection.

Family CYTHERELLIDAE Sars,
1865 (1866)
Genus MICROCHEILINELLA Geis, 1933
MICROCHEILINELLA ACUMINATA
Coryell and Rozanski, n. sp.
Plate 24, figure 18

Carapace smooth, medium to large, elongate, oblong; left valve larger than right; dorsal view subovate, sides subparallel, diverging slightly posteriorly, curving in abruptly at the ends; anterior end acuminate; left valve projects beyond the right posteriorly; end view subcircular, flattened dorsoventrally; dorsum and ventrum subparallel; ventrum straight to broadly rounded; anterior with a blunt acumination below the median point, with a straight steep slope from the dorsum to the acumination and a more gentle slope to the ventrum. Greatest height in anterior half; greatest thickness in the posterior half, and greater than the height; hinge straight; left valve overlaps the right distinctly anteriorly, narrowly and in part indistinctly posteriorly and ventrally; valves appear to meet evenly along the hinge line. Length, 0.65 mm., height, 0.22 mm., thickness, 0.25 mm.

Occurrence.—Basal bed in the Bluff section.

Holotype.—Columbia University micropaleontological collection.

MICROCHEILINELLA OVATA
Coryell and Rozanski, n. sp.
Plate 24, figure 19

Carapace small, subovate, left valve larger and overlaps the right, less conspicuously on the ventral border; surface smooth; valve surface strongly convex curving sharply into flattened dorsal and ventral surfaces; dorsum broadly convex, subparallel to the ventrum, anterior broadly rounded, curving evenly into dorsal and ventral margins; posterior margin rounding sharply into the narrow ventrum; ventrum with a forward swing; dorsal view broadly ovate; end view oblate; greatest length and height approximately median; greatest thickness in posterior half. Length, 0.44 mm., thickness, 0.21 mm., height, 0.24 mm.

Occurrence.—Basal shaly limestone in the Bluff section.

Holotype.—Columbia University micropaleontological collection.

The Glen Dean form is much thicker and higher than *M. perbracilis* Croneis and Gale, and it lacks the conspicuously complete overlap of that form.

Genus CAVELLINA Coryell, 1928
CAVELLINA CRONEISI
Coryell and Rozanski, n. sp.
Plate 24, figure 24

Carapace large, subovate, right valve larger; surface moderately convex, sloping evenly to the anterior margin and more abruptly near the remaining contacts. Dor-

sum very broadly arched; posterior margin broadly curved, trending gently anteriorly to the ventrum and sharply curved at the postcardinal angle; anterior end is more narrowly curved; ventrum straight to slightly concave; dorsal view ovate; convexity of valve smooth, sloping evenly to anterior contact and curving abruptly to the posterior contact; greatest length and height approximately median; greatest thickness in posterior half; right valve overlaps the left all around, strongly ventrally and dorsally, narrowly posteriorly, and slightly anteriorly. The anterior half of the holotype is finely and faintly reticulate. Young moults of this species, preserving the characteristic outline, may be relatively more inflated posteriorly. Length, 1.07 mm., height, 0.63 mm., thickness, 0.28 mm.

Occurrence.—Bluff and Frailey's store sections.

Holotype.—Columbia University micropaleontological collection.

The new species is named in honor of Carey Croneis.

C. coryelli Croneis and Gale and *C. marmorea* Kellett differ in post-dorsal slope and apparently lack the posterior truncation of *C. croneisi.*

Genus CAVELLINELLA Bradfield, 1935

CAVELLINELLA MOREYI

Coryell and Rozanski, n. sp.

Plate 24, figures 25, 26

Carapace of medium size, suboval, right valve larger than left, with a posterior curved ridge. Greatest convexity of valves in ventral half, sloping evenly to dorsal margin and curving abruptly to the other contacts; greatest length and height approximately median; greatest thickness in posterior half; dorsum arched, slopes subequal; anterior margin broadly rounded; posterior margin somewhat subacuminate about median point with a ventral forward swing; ventrum slightly convex or straight; right valve overlaps left strongly centrodorsally and centroventrally, distinctly anteriorly, and very narrowly at posterior end. Dorsal view cuneate, end view ovate; posteriorly the convexity of the valve is ornamented by a curved ridge, convex posteriorly. The valve is marked by small pits anterior to the ridge and pits are faintly indicated on the anterior quarter of the valve. Length, 0.67 mm., height, 0.40 mm., thickness, 0.24 mm.

Holotype.—Columbia University micropaleontological collection.

This species is named in honor of Phillip S. Morey.

Differs from *C. casei* Bradfield in location of posterior ridge and the presence of pits.

Family CYPRIDAE Baird, 1850

Genus HAWORTHINA Kellett, 1935

HAWORTHINA SALMONAE

Coryell and Rozanski, n. sp.

Plate 24, figures 22, 23

Carapace small, subreniform, inequivalved, smooth. Greatest length above the median line; greatest height slightly posterior to the center; greatest thickness posterior. Dorsum broadly arched; anterior margin regularly curved, bending sharply into the ventral margin; posterior somewhat more narrowly rounded, ventrum medially concave. The left valve overlaps the right on the free margins, overlap strong midventrally; valve contacts indistinct on postdorsal slope; the right valve is somewhat higher than the left along a portion of the anterodorsal slope; dorsal view cuneate, sides compressed, curving steeply to the end contacts. Length, 0.5 mm., height, 0.25 mm., thickness, 0.2 mm.

Occurrence.—Shaly limestone near the base of the Bluff section.

Holotype.—Columbia University micropaleontological collection.

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OSTRACODES FROM THE UPPER MISSISSIPPIAN OF MONTANA

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ABSTRACT—An ostracode fauna from the Big Snowy group of Montana is described. All but four of the species are from the Otter formation. The fauna is considered to be Chester in age, closer affinities lying with the middle and upper Chester. *Paraparchites*, *Glyptopleura*, *Jonesina*, *Sansabella*, and *Bairdia* are the most common genera. One new genus, *Lochriella*, is proposed.

PALEONTOLOGIC and stratigraphic studies of the Big Snowy group of late Mississippian age were undertaken by the writer several years ago at the suggestion of Dr. F. A. Thomson, Director of the Montana Bureau of Mines and Geology. A preliminary report (Scott, 1935) on the stratigraphic relationship of the Quadrant to the Big Snowy was made in 1935. Since then the fossils have been studied in more detail and because they have considerable value in regional correlation, as well as for subsurface correlation in the deep wells which have recently been drilled for oil in Montana and North Dakota, it seems advisable to report on the ostracodes which have been collected from surface exposures in central Montana. No attempt is made either to describe the complete ostracode fauna or to attempt correlation with any subsurface units.

Some of the ostracodes were sorted out and studied in a preliminary way by Mr. J. C. Rabbitt of the Montana Bureau of Mines and Geology. His work has greatly facilitated the preparation of this report.

The Big Snowy group consists of the Mississippian strata above the Madison limestone in central Montana. The group is composed of three formations, the Kibbey, Otter, and Heath. The first two formations were named by Weed (1899) from excellent exposures along Otter Creek near Kibbey, Montana. The name Heath (Scott, 1935) was applied to Mississippian strata above the Otter and the three formations included under the group name of Big Snowy.

The Kibbey is essentially a basal red sandstone, which locally contains thick gypsum beds, and is barren of fossils. The Otter is primarily a succession of shales and thin limestones. Green colors predominate in the shales, especially in the upper portion, although some gray to black shales occur in most sections. The thin limestones are often oolitic and ripple-marked. Ostracodes are common in some of the calcareous shales as well as in some of the thin limestones. The upper division of the Big Snowy group, the Heath, is composed essentially of black shale and lenticular sands.

No previous work has been done on Carboniferous ostracodes from Montana. In fact, very little study has been made of any Paleozoic microfossils from any portion of the geologic column in the Northern Rocky Mountains. Morey (1935) described an ostracode fauna from the Sacajawea (lower portion of the Amsden) of Wyoming and suggested that the formation is probably of St. Genevieve age. After a study of the megascopic fauna of the Sacajawea Branson (1937) also correlates it with the St. Genevieve. Croneis and Funkhouser (1938, p. 334) suggest, after a study of Chester ostracodes, that the forms described by Morey are more closely related to Chester species than to St. Genevieve.

Big Snowy ostracodes are closely related to those described from the Chester, especially from the Golconda, Menard, and Clore formations. They are also very similar to some forms from the Mauch Chunk (Reynolds member) of Virginia. *Paraparchites nicklesi* (Ulrich), *P. inornatus* (McCoy), *Sansabella reversa* Morey, *Jonesina puncta* Morey, and *Cavellina mediocris* Croneis and Thurman, are present in both the Chester and Otter faunas. Other species such as *Glyptopleura gloriosa* Scott, n. sp., *Glyptopleura quadricostata* Scott, n. sp., and *Glyp-*

topleurites windfieldi Scott, n. sp., are closely related to middle and upper Chester species.

C. L. Cooper of the Illinois Geological Survey reports (oral communication) that *Sansabella reversa* Morey, is common in the Clove formation. It is also common in the Sacajawea and Otter formations. Cooper has also collected several specimens of *Amphissites* from the middle and upper Chester which are related to *A. warei* Morey. In Cooper's collection are several specimens which appear to be closely related to what is described in this paper as *Lochriella otterensis* Scott, n. sp. *Microcoelonella symmetrica* Scott, n. sp., and *Geffenina reticulata* Scott, n. sp., are very closely related to Mauch Chunk species. It may be concluded, therefore, that the ostracodes from the uppermost part of the Otter formation (about 250–300 feet above the base) appear to be most similar to middle and upper Chester faunas. No evidence is at present available which would prove the lower or upper limit of the Otter in terms of the standard Chester section, but some of the ostracodes, long range species excluded, occur as low as the Golconda and others as high as the Clore.

Several of the species described by Morey from the Sacajawea of the Wind River mountains, Wyoming, occur in the Big Snowy fauna. *Sansabella reversa*, *S. amsdenensis*, *Jonesina? dubia*, *J. puncta*, *Bairdia contracta*, *Bythocypris amsdenensis*, and *Ellipsella? disjuncta* are known from both faunas. The ostracode fauna from the Otter is certainly related to the one described by Morey from the Sacajawea. This does not necessarily mean that the two formations are stratigraphic equivalents; similarity in facies would exist even if the Sacajawea was as old as the lower part of the Big Snowy (Kibbey). Branson (1939) correlates the Sacajawea with the St. Genevieve and Kibbey. Data obtained from the ostracode faunas suggest that the Sacajawea may extend into the Chester and be in part equivalent to the Otter.

The age of the Heath formation cannot be conclusively determined from the few ostracodes so far found in that zone. *Bairdiacypris puntata* Scott, n. sp. from the upper two feet of the Heath looks like a Pennsylvanian form. A few unidentified or new species of *Paraparchites* and *Sonesina* are of little if any aid. Studies now in progress on a large megascopic fauna may give the true answer.

For purposes of subsurface correlation *species of Glyptopleura, Glyptopleurites, Sansabella*, and *Lochriella* will prove most satisfactory. *Lochriella otterensis* Scott, n. sp. is the most abundant and characteristic of Otter ostracodes.

SYSTEMATIC DESCRIPTIONS

Class CRUSTACEA
Order OSTRACODA Latreille
Family LEPERDITELLIDAE
Ulrich and Bassler
Genus PARAPARCHITES Ulrich
and Bassler, 1906

PARAPARCHITES NICKLESI (Ulrich)

Leperditia nicklesi ULRICH, *1891*, Cincinnati Soc. Nat. History Jour., vol. 13, p. 200, pl. 18.

This is a fairly common Big Snowy ostracode. The species can be found in most outcrops of the Otter formation. Considerable variation exists in the size and shape of this species. Only a few specimens were found which possessed spines and in one instance the best developed spine occurs on the right valve instead of the left. Girty often found a spine on the left valve but never on the right on specimens from the Moorefield shale.

Type.—Hypotype, Univ. of Ill. Paleontology coll., no. x-1279.

Localities.—A, B, and D.

PARAPARCHITES EMACIATUS
Scott, n. sp.
Plate 25, figure 1

Carapace subquadrate in lateral view, compressed; dorsum straight; venter broadly and evenly convex; greatest height median, greatest length median; ends broadly rounded; anterior extremity below mid-height. Dorsal view subcuneate, greatest thickness in posterior half, anterior end acuminate, hinge straight, occupying about one-half the shell length, slightly impressed. Valves unequal, the right overlapping the left strongly around the free margin; left valve slightly raised above margin of right along dorsum; valves thick, smooth. Length 0.92 mm.; height, 0.70 mm.; thickness, 0.33 mm.

Type.—Holotype, Univ. of Ill. Paleontology coll., no. x-1280.

Locality.—C; Otter formation.

Remarks.—This species is recognized by its subquadrate outline, thinness in anterior half, and strong overlap.

PARAPARCHITES BIGSNOWYENSIS
Scott, n. sp.
Plate 25, figures 6, 7

Carapace small, with little backward swing in lateral view and sharply angulated in the antero-dorsal region; greatest extension of anterior end above median line, greatest extension of posterior end below median line; dorsum straight, venter broadly convex; greatest height in mid-section; dorsal view ovate, greatest thickness in ventral middle third. Valves unequal, the left valve slightly the larger and over-lapping the right; overlap strongest along ventral margin, very slight on each end; hinge line straight, no overlap along hinge, carapace smooth, valves thick. Measurements of an average sized specimen; length, 0.75 mm.; height, 0.46 mm.; thickness 0.34 mm.

Type.—Holotype, Univ. of Ill. Paleontology coll., no. x-1281.

Locality.—B; Otter formation.

Remarks.—This is one of the most common ostracodes in the Big Snowy. An ontogenetic series of *P. bigsnowyensis* shows that the lateral and dorsal outlines remain about the same. The dorsal outline does not become more tumid with age as is the case with *P. humerosus* as described by Kellett. However, there is some variation in the tumidity of specimens of the same size.

This form is classified as *Paraparchites* instead of *Antiparaparchites* even though the left valve overlaps the right ventrally. Reversal of overlap in otherwise similar forms is probably not of generic value, and in some known cases not of specific value. The character of the hinge-line is more similar to the description given by Kellett for *Pseudoparaparchites*, but none of the specimens possess an antero-dorsal spine typical of that genus.

PARAPARCHITES INORNATUS (McCoy)
Plate 26, figure 3

Cythere inornata McCOY, *1844*, Syn. Char. Carb. Fossils, Ireland, p. 167, pl. 23, fig. 18.
Paraparchites inornatus, HARLTON, *1927*, Jour. Paleontology, vol. 1, p. 203, pl. 32, figs. 1a, b.

Locality.—C; Otter formation.

Genus MICROCOELONELLA Coryell and Sohn, 1939

MICROCOELONELLA SYMMETRICA
Scott, n. sp.
Plate 25, figures 26, 27

Carapace ovate; dorsum short, gently convex; venter gently convex; ends broadly and similarly rounded; dorsal view elliptical, greatest thickness at mid-point, ends similarly rounded; hinge depressed into a canoe-shaped channel in middle half of dorsum, channel ends where overlap begins; valves unequal, right overlaps left around free margin; valves smooth, thick. Length, 0.86 mm.; height, 0.60 mm.; thickness, 0.30 mm.

Type.—Holotype, Univ. of Ill. Paleontology coll., no. x-1282.

Locality.—C; Otter formation.

Family KLOEDENELLIDAE
Ulrich and Bassler
Genus SANSABELLA Roundy, 1926

Persansabella CORYELL and SOHN, *1938*, Jour. Paleontology, vol. 12, no. 6, p. 598.
Reversabella CORYELL and JOHNSON, *1939*, Jour. Paleontology, vol. 13, no. 2, p. 221.

SANSABELLA REVERSA Morey
Plate 25, figures 28, 29
Plate 26, figures 15, 16

Sansabella reversa MOREY, *1935*, Jour. Paleontology, vol. 9, no. 6, p. 476, pl. 54, fig. 6.
Reversabella reversa, CORYELL and JOHNSON, *1939*, Jour. Paleontology, vol. 13, no. 2, p. 221, pl. 26, figs. 12a, b.

This is one of the most common species in the Otter formation. It is definitely related to *S. gunnari* Coryell and Johnson, differing only in reversal of overlap. Considerable confusion exists concerning the classification of this type of *Sansabella*. Morey follows the orientation of Roundy in which the left valve is the larger and applies the name *S. reversa* to a form with reversed overlap. Coryell and Johnson follow Geis in which they consider the right valve the larger and establish the new genus *Reversabella* to receive those sansabelloid forms in which the left valve overlaps the right.

It is entirely possible that the forms assigned to *S. reversa* Morey and *S. gunnari* Coryell and Johnson are sinistral and dextral forms of the same species. In all the specimens that I have studied from the Ot-

ter formation the right valve overlaps the left (following Roundy's orientation). If the orientation proposed by Geis was followed the form here classified as *S. reversa* Morey would be classified as *S. gunnari* Coryell and Johnson.

Type.—Hypotype, Univ. of Ill. Paleontology Coll., no. x-1278.

Locality.—B; Otter formation.

SANSABELLA BELLA Scott, n. sp.
Plate 25, figures 12, 13

Carapace subovate, strongly convex; dorsum essentially straight, a slight convexity in posterior third; venter straight to slightly convex, parallel to dorsum; anterior and posterior ends broadly and uniformly rounded; anterior and posterior cardinal angles equally obtuse. Greatest length median, greatest thickness in posterior half. Valves unequal, the right overlapping the left around the free border, overlap strongest along ventral margin. Surface of valves marked by a narrow, relatively deep elongate pit which begins slightly anterior of midpoint and extends about half way to dorsal margin. A small node occurs along the dorsal margin immediately posterior to pit. Dorsal edges reflexed to form a V-shaped channel, deepest in posterior third; hinge line straight, occupying three-fourths of shell length. Dorso-posterior half of valves tumid, projecting above margins of channeled dorsum. Length, 0.70 mm.; height, 0.46 mm.; thickness, 0.30 mm.

Type.—Holotype, Univ. of Ill. Paleontology Coll., no. x-1283.

Locality.—A; Otter formation.

SANSABELLA AMSDENENSIS Morey
Plate 26, figure 17

Sansabella amsdenensis MOREY, *1935*, Jour. Paleontology, vol. 9, no. 6, p. 475, pl. 54, fig. 17.

Type.—Hypotype, Univ. of Ill. Paleontology Coll., no. x-1311.

Genus LOCHRIELLA Scott, n. gen.

Carapace subrectangular to ovate; cardinal angles obtuse, greatest thickness in posterior half; valves unequal, right overlapping left around free margin; hinge line depressed in channel, channel occupies posterior one-half to two-thirds of dorsal area; valves may or may not be constricted slightly anterior to middle, if constricted a broad shallow sinus is formed. Carapace smooth or reticulate.

Genotype.—*Lochriella otterensis* Scott, n. sp.

Remarks.—This genus is closely related to *Sansabella*. The posterior position of the channel, the difference in hingement, and the point of greatest thickness readily distinguish it from *Sansabella*. It can be distinguished from *Beyrichella* by the absence of a low transverse ridge and by the presence of a channeled dorsum. It differs from *Jonesina* by the presence of a channel in the posterior portion of the dorsal area and the lack of a distinct sinus. It can be distinguished from *Neokloedenella* by the presence of an overlap around the free margin.

LOCHRIELLA OTTERENSIS
Scott, n. sp.
Plate 25, figure 30, 31

Carapace subovate in lateral view; dorsum straight to slightly convex; venter broadly convex; greatest length median, greatest height slightly posterior to center, greatest thickness in posterior half. Anterior cardinal angle obtuse, anterior margin truncated dorsally, greatest extension of anterior just below middle; posterior cardinal angle obtuse, posterior margin broadly curved, slightly truncated ventrally. Dorsal view cuneate, posterior end rounded and thick, anterior rather sharp. Valves unequal, the right overlapping the left around the free margin, the overlap being strong ventrally and anteriorly but slight in dorso-posterior, ventral overlap forms sharp incurved ridge on right valve and causes a flattening of the left valve along ventral margin. Hinge line straight, occupying three-fourths of shell length, greatly impressed forming pronounced channel which widens posteriorly and is terminated anteriorly by overlap, posterior end of hinge slightly raised where gently overlap begins; shallow depressions extend posteriorly from channel along each side of raised hinge tip; valves thick, smooth. Length, 0.86 mm.; height, 0.60 mm.; width, 0.40 mm.

Type.—Holotype, Univ. of Ill. Paleontology Coll., no. x-1287.

Localities.—B, C; Otter formation.

Remarks.—*Lochriella otterensis*, the most common Otter species, can be distinguished

from *Sansabella reversa* Morey by the more obtuse anterior cardinal angle, the position of the channel, and the point of greatest thickness. It is also similar in lateral view to *Sansabella amsdensis* Morey but they are readily separated in dorsal view by the position of the channel and the character of the posterior cardinal point.

LOCHRIELLA SEAGERI Scott, n. sp.
Plate 25, figures 22–25

Carapace subrectangular in lateral view; dorsum straight in anterior half, convex in posterior half; venter straight to gently concave; greatest height and thickness in posterior half; greatest extension of anterior just below middle, anterior margin truncated dorsally; greatest extension of posterior end at midpoint where right valve extends in a sharply rounded tip; broad shallow sinus anterior of middle in dorsal half. The posterior dorsal half of each valve raised above hinge line, right valve raised slightly higher than left. Dorsal view subcuneate; valves unequal, right overlapping left around free margin, overlap strongest in mid-half of venter and on posterior end. Hinge line long, impressed in posterior half in a channel; sharp tooth at each end of hinge in right valve set in socket of left valve; channel in posterior half widens posteriorly and continues in right valve as a short narrow sinus. Length, 0.90 mm.; height, 0.50 mm.; width, 0.38 mm.

Type.—Holotype, Univ. of Ill. Paleontology Coll., no. x-1284.

Locality.—This species was obtained from well cuttings from the Cat Creek Oil field and locality D. Top of Otter formation.

Remarks.—Male specimens of *L. seageri* do not possess a broad shallow sinus and therefore are not as tumid in the posterior half. The continuation of the channel posteriorly in the right valve as a sinus and the posterior extension of the right valve at midpoint into a rounded tip are the most characteristic features of this species.

LOCHRIELLA SUBVENTRICOSA
Scott, n. sp.
Plate 26, figures 9, 10

Carapace subovate to subquadrate, medium sized. Dorsum straight; venter straight, parallel to dorsum. Greatest length median, greatest thickness posterior. Carapace coarsely punctate; broad, shallow depression slightly anterior of median line; posterior half of valves strongly convex. Valves unequal, right overlapping left around the free margin. Dorsal view subcuneate, posterior half moderately inflated. Hinge straight, three-fourths length of carapace, impressed in elongate channel which widens posteriorly; greatest width of channel opposite greatest thickness of carapace. The channel continues posteriorly in right valve as a narrow, shallow trough beyond cardinal point where overlap begins. Length, 0.75 mm.; height, 0.46 mm.; thickness, 0.38 mm.

Type.—Holotype, Univ. of Ill. Paleontology Coll., no. x-1286.

Locality.—D; Heath formation.

Genus JONESINA Ulrich
and Bassler, 1908

JONESINA PUNCTA Morey

Jonesina? puncta MOREY, *1935*, Jour. Paleontology, vol. 9, no. 6, p. 476, pl. 54, fig. 1.
Jonesina puncta, CORYELL and JOHNSON, *1939*, Jour. Paleontology, vol. 13, no. 2, p. 214, pl. 26, fig. 3.

This is not a common species in the Big Snowy group. A few specimens were found in the top of the Otter.

Type.—Hypotype, Univ. of Ill. Paleontology Coll., no. x-1306.

JONESINA? DUBIA (Morey)

Sansabella? dubia MOREY, *1935*, Jour. Paleontology, vol. 9, no. 6, p. 476, pl. 54, fig. 21.

This species is included under *Jonesina* because of the presence of a sulcus. It is fairly common in the Otter.

JONESINA ARCUATA? (Bean)

Cypris arcuata, BEAN, *1836*, Mag. Nat. Hist., vol. 9, p. 377, fig. 55.

The few specimens referred to this species are almost identical to the one figured by Ulrich and Bassler (U. S. Nat. Mus., vol. 35, pl. 44, fig. 19). The Montana specimens are slightly smaller. The species appears to have a long stratigraphic range and may be of little value in correlation.

Type.—Hypotype, Univ. of Ill. Paleontology Coll., no. x-1307.

JONESINA FRAGILIS Scott, n. sp.
Plate 26, figure 7

Carapace subovate, thin, small, with a pronounced retral ventral swing. Dorsum straight; venter broadly convex. Posterior cardinal angle more obtuse than anterior cardinal angle. Greatest height slightly posterior of center, greatest thickness median. Posterior half of carapace marked by two shallow depressions, the larger extending from the dorsum three-fourths of the distance to the venter and situated slightly behind the median line, the smaller occurring in the dorso-posterior quarter; a gentle node separates the two depressions. Valves unequal, left overlaps right slightly around free margin; valves thin, delicate; surface finely granular. Hinge characters unknown. Length, 0.86 mm.; height, 0.46 mm.

Type.—Holotype, Univ. of Ill. Paleontology Coll., no. x-1288.

Locality.—D; Heath formation.

Remarks.—Four specimens of this species were found in a black shale but only the left valves were well preserved. The thin, fragile carapace is not characteristic of any other species of this genus from the Big Snowy group. It is very similar in shape to *J. arcuata*.

JONESINA LOMBARDENSIS
Scott, n. sp.
Plate 26, figure 8

Carapace subovate, small; dorsum straight, venter broadly convex. Greatest extension of anterior end above mid-line, of posterior end below mid-line; antero-dorsal slope short, postero-dorsal slope long. Greatest height in posterior third, greatest thickness slightly anterior of midpoint. Surface marked by a narrow, shallow sulcus slightly posterior to median line; inconspicuous node posterior to sulcus and faint depression posterior to node. Valves unequal, left overlapping right around free margin; greatest overlap along venter; dorsal view elongate-ovate; hinge long, straight, very slightly impressed, slightly off-set where overlap begins. Length, 0.83 mm.; height, 0.50 mm.; thickness, 0.30 mm.

Type.—Holotype, Univ. of Ill. Paleontology Coll., no. x-1289.

Locality.—D; Otter formation.

Remarks.—*J. lombardensis* differs from *J. arcuata* in that the carapace is more rectangular and thicker.

JONESINA? JUDITHENSIS
Scott, n. sp.
Plate 25, figures 16, 17

Carapace subovate to subrectangular, medium sized. Dorsum broadly convex; dorsal margin of left valve straight; dorsal edge of right valve convex, abruptly elevated above edge of left in mid-portion; venter broadly convex. Greatest length median, greatest height median. Surface of left valve marked by a deep, well defined sulcus which is slightly anterior of mid-length; sulcus constricted in middle, widens dorsally and ventrally, deepest at constriction; surface of left valve ventral to sinus sharply convex, posterior to sinus strongly inflated. Surface of right valve marked by a subcircular, well defined, large depression which is subcentrally situated and does not extend as a sulcus to the dorsal margin. Valves unequal, right strongly overlapping left around the free margin, greatest overlap along ventral margin. Dorsal view elongate-ovate, sides sub-parallel in middle two-thirds, sharply convex near each end; hinge straight, long, impressed, off-set at cardinal angles where overlap begins. Length, 0.91 mm.; height, 0.60 mm.. thickness, 0.42 mm.

Type.—Holotype, Univ. of Ill. Paleontology Coll., no. x-1295.

Locality.—B; Basal Otter formation.

Remarks.—This species is readily identified by the sulcus on the left valve, the large pit on the right valve, and the bulbous appearing posterior end in lateral view.

JONESINA PAPEI
Scott, n. sp.
Plate 26, figures 11, 12

Carapace subovate to subrectangular, medium sized. Dorsum broadly convex; dorsal margin of right valve convex and slightly elevated above straight margin of left valve in mid-portion; venter broadly convex. Greatest length median, greatest height median, greatest thickness ventral to sulcus. Surface of left valve marked by a deep, well defined sulcus which is slightly anterior of mid-length; sulcus gently constricted at midpoint. Surface of valve sharply convex ven-

tral to sinus, gently convex posterior and anterior to sinus. Surface of right valve marked by a large, shallow, subcircular pit situated near mid-point of carapace. Valves unequal, right overlapping the left around the free margins, greatest overlap along venter. Dorsal view elongate-ovate; hinge straight, long, slightly impressed, off-set at cardinal angles where overlap begins. Length 0.87 mm.; height, 0.47 mm.; thickness, 0.33 mm.

Type.—Holotype, Univ. of Ill. Paleontology Coll., no. x-1296.

Locality.—B; Otter formation.

Remarks.—*J. papei* is very similar to *J. judithensis* but the two species can be distinguished by the more elliptical outline in dorsal view, the less prominent sulcus, and the less inflated posterior half of the former.

Genus GEFFENINA Coryell and Sohn, 1938

GEFFENINA RETICULATA
Scott, n. sp.
Plate 26, figures 1, 2

Carapace subrectangular in lateral view; dorsum and venter subparallel; ends rounded, greatest extension of anterior end slightly above mid-height, greatest extension of posterior end slightly below mid-height. Anterior node is a broad swelling, rising slightly above hinge line, occupying the anterior half of the valve. The posterior node is situated at a distance of one-fourth of the carapace length from the posterior end, separated from anterior swelling by a deep sulcus. The medial sulcus is narrow and deep ventrally, but becomes broad and shallow near the dorsal margin. Ventral ridge faintly developed ventral to sulcus, swings broadly around posterior end becoming distinct in dorso-posterior area where it is separated from posterior node by a shallow sulcus. Dorsal view thickly wedge-shaped, greatest thickness in anterior half, prominent constriction at median sulcus; anterior half of dorsum channeled, channel continues posteriorly into medial sulcus on right valve; hingement sansabelloid. Valves unequal, left overlapping right around free margin. Surface covered with fine reticulae. Length, 1.00 mm.; height, 0.60 mm.; width, 0.46 mm.

Type.—Holotype, Univ. of Ill. Paleontology Coll., no. x-1304.

Remarks.—This species from the Otter formation is very closely related to *G. marmerae* Coryell and Sohn from the Mauch Chunk of West Virginia. The Montana species differs in having a less prominent posterior node, a narrow medial sinus ventrally, and a partially channeled dorsum. The perfectly preserved Montana specimens have a finely reticulated surface; on poorly preserved specimens the reticulae are faint or entirely absent. The presence or absence of reticulae on fossil ostracodes may often be a matter of preservation.

Genus EUKLOEDENELLA Ulrich and Bassler, 1923

EUKLOEDENELLA DISTRESSA
Scott, n. sp.
Plate 26, figures 13, 14

Carapace medium sized, elongate, subrectangular in outline; dorsum straight; venter broadly convex. Greatest thickness slightly below and posterior of median point. Posterior cardinal angle approximately 100°; anterior cardinal angle broadly rounded. Valves thin, subequal; overlap indistinct; surface sometimes marked with a broad shallow depression slightly dorsal of mid-point, otherwise smooth. Length, 0.83 mm.; height, 0.44 mm.; thickness, 0.30 mm.

Type.—Holotype, Univ. of Ill. Paleontology Coll., no. x-1303.

Locality.—B; Otter formation.

Remarks.—Several specimens of this species occur in my collection. The valves appear to be thin and relatively fragile. Most of them are distorted in such a manner that the dorsal margin becomes sharply concave in the anterior half and thus increases the tumidity in the ventral area. The dorsal concavity occurs so frequently that it might easily be mistaken as a true shell character. Some specimens show shallow pits near the mid-point of the carapace and directly above the zone of maximum tumidity.

This species is similar to *Neokloedenella subquadrata* Croneis and Gutke from the Renault, but *E. distressa* does not have a grooved hinge line and the point of greatest thickness is more ventral. *Neokloedenella* Croneis and Funkhouser is probably a synonym of *Eukloedenella*.

Genus LOKIUS Coryell and Johnson, 1939

LOKIUS CORYELLI Scott, n. sp.

Plate 26, figures 5, 6

Carapace small, subrhomboidal, inequivalved; dorsum straight; venter broadly convex. Greatest extension of anterior end above median line; greatest extension of posterior end median; greatest height in posterior half. Surface marked by a prominent sulcus, slightly posterior to mid-length, bordered by low anterior and posterior swellings. Small, inconspicuous, shallow sinus below posterior cardinal angle; ventral to median sinus is an elongate backward sloping ridge confined to the middle half of the valves. Antero-dorsal portion of valves marked by a low inconspicuous ridge that begins along dorsal edge as a shoulder and then swings ventrally fading out in the antero-dorsal quarter of the valves. Left valve overlaps right along free margin. Dorsum broad and flat in anterior half, narrow and flat in posterior half; hinge line straight. Length, 0.63 mm.; height, 0.46 mm.; width, 0,26 mm.

Type.—Holotype, Univ. of Ill. Paleontology Coll., no. x-1316; paratype, x-1317.

Locality.—A; Otter formation.

Remarks.—Coryell and Johnson classify *Lokius* under the Acronotellidae. The genus is here classified under the Kloedenellidae because it seems to be closer related to *Jonesina* and *Beyrichella* than it is to *Monoceratina*.

Family GLYPTOPLEURIDAE Girty

Genus GLYPTOPLEURA Girty, 1910

GLYPTOPLEURA BICARINATA Scott, n. sp.

Plate 25, figure 11

Carapace oblong in lateral view, dorsum straight and venter broadly convex; ends rounded, antero-ventral portion somewhat truncated, greatest height median, greatest length median. Carapace subelleptical in dorsal view, both ends evenly blunt, greatest thickness at the center; hinge-line occupies three-fourths of shell length, slightly impressed forming shallow trough and ridge-like shoulders along dorsum of each valve; valves thick. Two primary costae on right valve roughly paralleling dorsum and venter, one slightly above median line and the other slightly below thus dividing the valve into three subequal parts; costae start near posterior margin, traverse the shell length and almost meet in a closed loop near anterior margin. Two primary costae on left valve start in posterior third, extend to point near anterior margin where they meet in a sharp loop; a secondary costa slightly below lower primary one parallels the latter for part of its length and disappears in the anterior and posterior thirds; another secondary costa in anterior half merges into lower primary costa. A ridge in antero-dorsal half forms closed loop with upper primary costa; similar costa extends from posterior end of upper primary one along postero-dorsal margin to near médian point where it meets a narrow sinus; shallow median pit just below upper primary costa. The valves are unequal in size, the right overlapping the left strongly around the ventral margin and slightly around the ends. Length, 0.88 mm.; height, 0.50 mm.; width, 0.33 mm.

Type.—Holotype, Univ. of Ill. Paleontology Coll., no. x-1290.

Locality.—C; Otter formation.

GLYPTOPLEURA GLORIOSA Scott, n. sp.

Plate 25, figures 2, 3

Carapace oblong in lateral view, strongly convex; both ends broadly rounded; dorsum straight, venter slightly convex, dorsum and venter sub-parallel for three-fourths of shell length; greatest length median; dorsal view subcuneate; posterior end blunt, anterior sharply rounded; greatest thickness in posterior third. Surface of valves marked with six slightly diagonal, inosculating costae, rising dorsally towards the posterior; a deep, round, subcentral pit is present between the second and third costae just anterior and slightly above the center, a smaller pit is present directly above where it interrupts the first rib; one short secondary rib occurs at the posterior end between the third and fourth primary costae, surface between costae appears flat. Valves unequal, right overlapping left along ventral margin; ventral surface broadly convex; hinge straight, long, occupying four-fifths of shell length, slightly impressed, forming broad, flat to gently con-

cave dorsal surface. Length, 1.00 mm.; height, 0.60 mm.; thickness, 0.42 mm.

Type.—Holotype, Univ. of Ill. Paleontology Coll., no. x-1291.

Locality.—A; Otter formation.

Remarks.—*G. gloriosa* is most similar to *G. menardensis* Harlton. It differs from the latter species in the weaker dorsal rib, shallow dorsal pit, longer hinge, and secondary costae. It is also similar to *G. multicostata* Morey, differing only slightly in type of costae; however, it is more rectangular and has a broader flat dorsal surface.

GLYPTOPLEURA QUADRICOSTATA
Scott, n. sp.
Plate 25, figure 10

Carapace subquadrate in lateral view; ends broadly and evenly rounded; dorsum broadly concave, venter broadly convex; surface marked with four low simple costae, one above and three below the median pit; costae fade out in posterior and anterior thirds, a deep, round, subcentral pit is present between the first and second costae just anterior and slightly above the center; a second smaller pit is present directly above the first extending toward the dorsum as a broad faintly defined trough; valves unequal, right overlapping left strongly along ventral margin; ventral surface broadly convex; hinge characteristics unknown. Length, 0.85 mm.; height, 0.60 mm.; thickness, 0.40 mm.

Type.—Holotype, Univ. of Ill. Paleontology Coll., no. x-1294.

Locality.—A; Otter formation.

Remarks.—*G. quadricostata* is similar to *G. gloriosa*, but differs in the more subquadrate form, fewer costae, and narrower dorsum.

Genus GLYPTOPLEURITES Coryell and Johnson, 1939

GLYPTOPLEURITES WINDFIELDI
Scott, n. sp.
Plate 25, figures 4, 5

Description of the male: Carapace short, subovate, moderately convex; posterior end

EXPLANATION OF PLATE 25
(All figures about ×25)

FIGS. *1*—*Paraparchites emaciatus* Scott, n. sp., left valve of holotype, U. I., x-1280, Otter formation. (p. 153)

2, 3—*Glyptopleura gloriosa* Scott, n. sp. *2*, Left valve. *3*, Dorsal view of holotype, U. I., x-1291, Otter formation. (p. 159)

4, 5—*Glyptopleurites windfieldi* Scott, n. sp. *4*, Right valve, male. *5*, Right valve, female. Holotype, U. I., x-1293, Otter formation. (p. 160)

6, 7—*Paraparchites bigsnowyensis* Scott, n. sp. *6*, Dorsal view. *7*, Left valve of holotype, U. I., x-1281, Otter formation. (p. 154)

8—*Bairdia* sp.? Otter formation.

9—*Bairdia polygonata* Scott, n. sp. Right valve, holotype, U. I., x-1298. (p. 161)

10—*Glyptopleura quadricostata* Scott, n. sp., right valve of holotype, U. I., x-1294, Otter formation. (p. 160)

11—*Glyptopleura bicarinata* Scott, n. sp., left valve of holotype, U. I., x-1290, Otter formation. (p. 159)

12, 13—*Sansabella bella* Scott, n. sp. *12*, Left valve. *13*, Dorsal view of holotype, U. I., x-1283, Otter formation. (p. 155)

14, 15—*Bairdia contracta* Morey. *14*, Right valve. *15*, Dorsal view of hypotype, U. I., x-1308, Otter formation. (p. 161)

16, 17—*Jonesina? judithensis* Scott, n. sp. *16*, Left valve. *17*, Right valve of holotype x-1295, Otter formation. (p. 157)

18—*Bythocypris amsdenensis* Morey, right valve. Hypotype, U. I., x-1309, Otter formation. (p. 162)

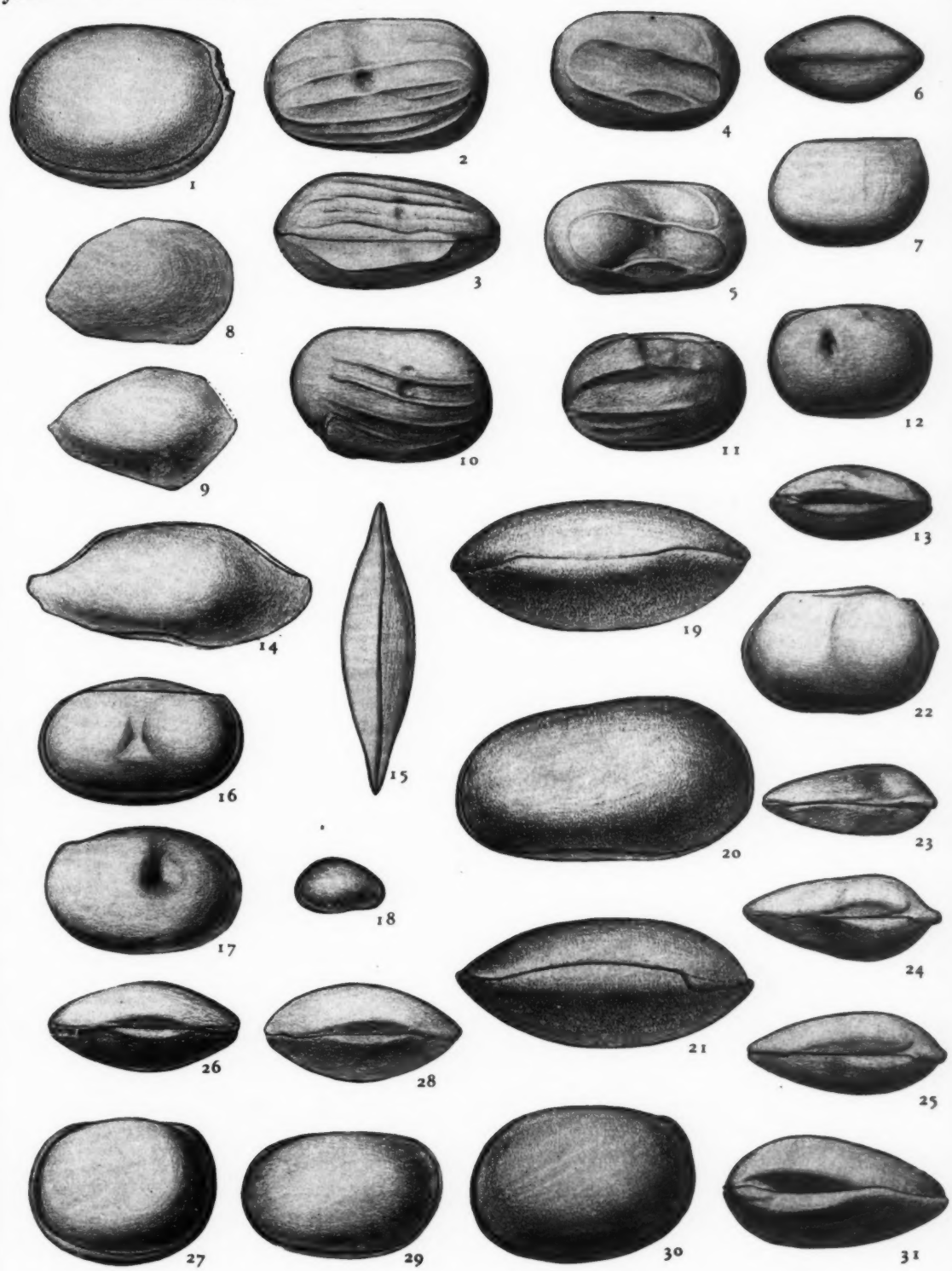
19–21—*Bairdiacypris punctata* Scott, n. sp. *19*, Dorsal view. *20*, Left valve. *21*, Ventral view. Holotype, U. I., x-1314, Otter formation. (p. 162)

22–25—*Lochriella seageri* Scott, n. gen. and n. sp. *22*, Left valve. *23*, Dorsal view of young specimen. *24*, Dorsal view. *25*, Dorsal view of male specimen. 22 and 24 are views of female. Holotype x-1284, Heath formation. (p. 156)

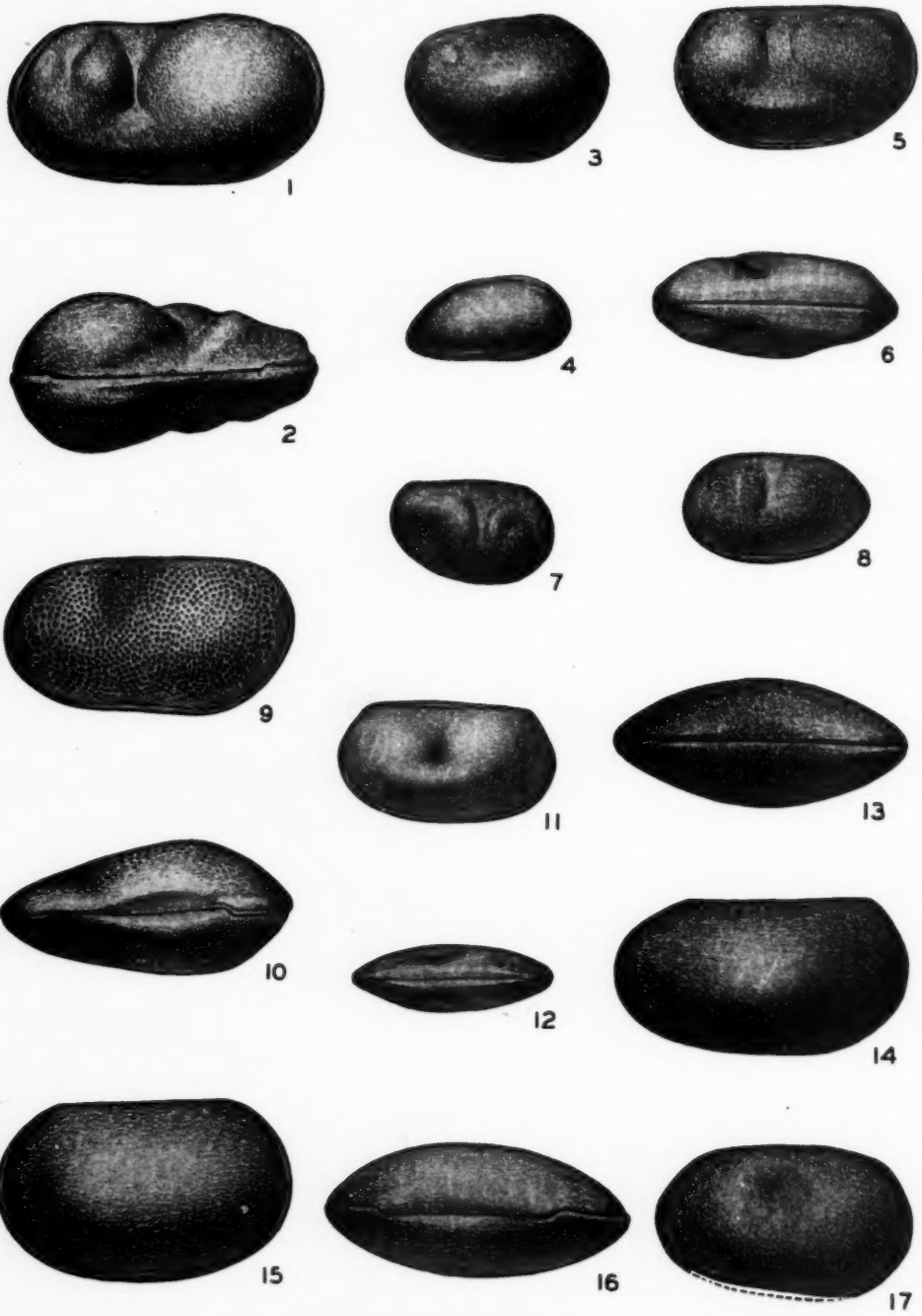
26, 27—*Microcoelonella symmetrica* Scott, n. sp. *26*, Dorsal view. *27*, Left valve of holotype, U. I., x-1282, Otter formation. (p. 154)

28, 29—*Sansabella reversa* Morey. *28*, Dorsal view. *29*, Left valve. Hypotype, U. I., x-1278, Otter formation. (p. 154)

30, 31—*Lochriella otterensis* Scott, n. sp. *30*, Left valve. *31*, Dorsal view. Holotype, U. I., x-1287, Otter formation. (p. 155)



Scott, Mississippian Ostracodes



Scott, Mississippian Ostracodes

broadly rounded with a short dorsal slope making an obtuse angle with the dorsal margin, longer ventral slope curves evenly into ventral margin; anterior end essentially the same but with a slightly longer dorsal slope; greatest length median; dorsum straight, venter broadly convex; surface marked with two inosculating costae joined at both ends to form a subelliptical loop, ventral rib divides in two at mid-length forming a small elongated loop in antero-ventral area; costae merge into faint rib which parallels anterior margin; an obscure subcentral pit is present between the two primary costae. Valves unequal, right overlapping tae left, overlap strongest along ventral and posterior margin; dorsal view subelliptical, ends about equally rounded, greatest thickness medially; hinge straight, occupying three-fourths of shell length, borders of the two valves rise above the hinge producing a narrow trough-like depression.

Description of the female: Carapace quadrate-elliptical; posterior and anterior ends evenly and similarly rounded; greatest length median, greatest height in posterior half; dorsum straight; venter sinuate; surface marked with two inosculating costae joined at both ends to form a subelliptical loop, ventral rib divides in two forming a small secondary loop in antero-ventral area; dorsal margin marked by strong rib that turns downward in antero-dorsal area and merges into dorsal costa; a large well developed pit occurs anterior to center between the two costae, directly above it and dorsal to the upper rib is a secondary pit; valves greatly inflated in postero-dorsal area, costae weakly developed where they pass over margins of inflated area. Length, 0.88 mm.; height, 0.46 mm.; thickness, 0.28 mm.

Type.—Holotype, Univ. of Ill. Paleontology Coll., no. x-1293.

Locality.—A; Otter formation.

Remarks.—The female of *G. windfieldi* has some resemblance to the specimen described as *G. tyri* Coryell and Johnson from the Chester. The primary difference between them is the presence of a medial costa emerging from a large node in *G. tyri*.

Superfamily CYPRIDACEA
Family BAIRDIIDAE Sars
Genus BAIRDIA McCoy, 1844

BAIRDIA CONTRACTA Morey
Plate 25, figures 14, 15

Bairdia contracta MOREY, *1935*, Jour. Paleontology, vol. 9, no. 6, p. 480, pl. 54, figs. 11, 12.

This species occurs in the upper part of the Otter.

Type.—Hypotype, Univ. of Ill. Paleontology Coll., no. x-1308.

BAIRDIA POLYGONATA Scott, n. sp.
Plate 25, figure 9

Carapace small, polygonal in lateral view; dorsum sharply arched; antero-ventral and postero-ventral slopes meet at point two-

EXPLANATION OF PLATE 26
(All figures about × 35)

FIGS. *1, 2—Geffenina reticulata* Scott, n. sp. *1*, Left valve. *2*, Dorsal view of holotype, U. I., x-1304, Otter formation. (p. 158)
3—Paraparchites inornatus (McCoy), left valve, Otter formation. (p. 154)
4—Pontocypris pulchra Scott, n. sp., right valve of holotype, U. I., x-1302, Otter formation. (p. 162)
5, 6—Lokius coryelli Scott, n. sp. *5*, Right valve. *6*, Dorsal view of holotype, U. I., x-1316, Otter formation. (p. 159)
7—Jonesina fragilis Scott, n. sp., left valve of holotype, U. I., x-1288, Otter formation. (p. 157)
8—Jonesina lombardensis Scott, n. sp., right valve of holotype, U. I., x-1289, Otter formation. (p. 157)
9, 10—Lochriella subventricosa Scott, n. sp. *9*, Left valve. *10*, Dorsal view of holotype, U. I., x-1286, Heath formation. (p. 156)
11, 12—Jonesina papei Scott, n. sp. *11*, Left valve. *12*, Dorsal view of holotype, U. I., x-1296, Otter formation. (p. 157)
13, 14—Eukloedenella distressa Scott, n. sp. *13*, Dorsal view. *14*, Left valve of holotype, U. I., x-1303, Otter formation. (p. 158)
15, 16—Sansabella reversa? Morey. *15*, Left valve. *16*, Dorsal view. Otter formation. (p. 154)
17—Sansabella amsdenensis Morey, left valve, Otter formation. (p. 155)

thirds of distance from posterior end forming an obtuse angle. Greatest length slightly below median, greatest height in anterior third, greatest thickness slightly below median line in anterior third. Anterior end sharply truncated along dorsal and ventral margins, antero-dorsal slope straight, equals hinge in length, the longer antero-ventral slope very gently convex, the two meeting in an obtuse angle along median line. Posterior end sharply acuminate, with a long dorsal slope meeting the ventral margin in an acute angle slightly below median line. Greatest convexity of carapace slightly below lateral median line. Valves subequal, overlap weak and obscure. Dorsal view lanceolate, ends acute. Length, 0.83 mm.; height, 0.50 mm.; thickness, 0.36 mm.

Type.—Holotype, Univ. of Ill. Paleontology Coll., no. x-1298.

Locality.—B; Otter formation.

Genus BYTHOCYPRIS Brady, 1880
BYTHOCYPRIS AMSDENENSIS
Morey, 1935
Plate 25, figure 18

Bythocypris amsdenensis MOREY, *1935*, Jour. Paleontology, vol. 9, no. 6, p. 481, pl. 54, figs. 2, 3.

Only one specimen of this species was found but it agrees in all respects with the form described by Morey from the Amsden.

Type.—Hypotype, Univ. of Ill. Paleontology Coll., no. x-1309.

Locality.—B; Otter formation.

Genus PONTOCYPRIS Sars, 1865
PONTOCYPRIS PULCHRA
Scott, n. sp.
Plate 26, figure 4

Carapace reniform in lateral view; dorsum broadly convex. Venter straight; anterior end rounded, with a long dorsal slope and a very short ventral slope; dorso-posterior margin broadly curved almost to ventral margin where curvature sharply changes and forms almost a right angle with ventral margin; greatest length in ventral third of carapace, greatest height median. Valves unequal, the left narrowly overlapping the right ventrally; elliptical in dorsal view, ventricose medially; hinge short, no overlap along dorsum; valves thin, surface smooth. Length, 0.60 mm.; height, 0.33 mm.; thickness, 0.28 mm.

Type.—Holotype, Univ. of Ill. Paleontology Coll., no. x-1301. paratype, no. x-1302.

Locality.—C; Otter formation.

Genus BAIRDIACYPRIS Bradfield, 1935

Bairdiacypris BRADFIELD, *1935*, Bull. Amer. Paleontology, vol. 22, p. 93.

Bairdiacypris was described by Bradfield from material collected from the Hoxbar formation, Oklahoma. This genus differs from *Bythocypris* primarily by the absence of overlap along the hinge line. The Montana specimens differ from the genotype in that the right valve is larger and overlaps the left around the free margin and that the surface is punctate. Neither of these features are considered to be of generic rank.

The choice of the word *Bairdiacypris* is unfortunate because it is similar to *Bairdiocypris* Kegel 1931, but according to the Rules of Nomenclature cannot be rejected. (See Recommendations, Article 36.)

BAIRDIACYPRIS PUNCTATA
Scott, n. sp.
Plate 25, figures 19–21

Carapace subrectangular, strongly convex; anterior and porterior ends broadly rounded. Dorsum straight; venter straight to gently convex, subparallel to dorsum. Greatest height in posterior half, greatest length ventral to median line. Elongate-ovate in dorsal view; ends sharply rounded; greatest thickness in posterior half. Valves unequal, right overlaps the left around free margin, overlap stops where hinge begins; greatest overlap on ventral margin slightly anterior to middle, least overlap on anterior end; dorsal margin of left valve raised slightly above edge of right. Hinge line straight, equal to two-thirds of shell length; mid-point of hinge line slightly posterior to mid-length of carapace. Valves covered with minute punctae. Length, 1.20 mm.; height, 0.70 mm.

Type.—Holotype, Univ. of Ill. Paleontology Coll., no. x-1314.

Locality.—D; Heath formation.

Remarks.—This species was found at the top of the Heath formation and looks very

much like a Pennsylvanian species. It is provisionally listed in the Big Snowy fauna.

Family CYTHERELLIDAE Sars
Genus CAVELLINA Coryell, 1928
CAVELLINA MEDIOCRIS Croneis and Thurman

Cavellina mediocris CRONEIS and THURMAN, *1938*, Dennison Univ. Bull., vol. 33, p. 327, pl. 7, fig. 17.
Cavellina ithunnae CORYELL and JOHNSON, *1939*, Jour. Paleontology, vol. 13, no. 2, p. 223, pl. 25, figs. 8a, b, c.

C. mediocris is rare in the Big Snowy group. Montana specimens have been compared with several collected from the Clore and the Kinkaid of southern Illinois and the only difference that can be noted between the species described by Croneis and Thurman is that a slight overlap is sometimes present on the anterior margin. *C. mediocris.* is very similar to *Cytherella bransoni* Morey from the Amsden. The only apparent difference is the greater convexity of the dorsal and ventral margins of the Amsden form. Length, 0.54 mm.; height, 0.33 mm.

Type.—Hypotype, Univ. of Ill. Paleontology Coll., no. x-1310.

Locality.—D; Otter formation.

LOCALITIES

A.—North bank Missouri River, ½ mile west of Lombard.

B.—East end of Little Belt Mountains about four miles due west of Judith Gap. Most of the ostracodes at this locality come from zone 28 (Scott, p. 1027, Table V, 1935).

C.—Red Hill, south side of Judith River, eight miles west of Utica.

D.—North flank of Big Snowy Mountains, sec. 6, T. 12 N., R. 20E.

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SOME TERTIARY OSTRACODA OF THE GENERA ALATACYTHERE AND BRACHYCYTHERE

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ABSTRACT—Four species of the new genus *Alatacythere* and 11 species of the genus *Brachycythere* are described and figured from the Tertiary of the Gulf Coastal Plain province of the United States. Among these are one new species of *Alatacythere* (*A. frinki*) and two new species of *Brachycythere* (*B. bernardi* and *B. martini*). Emphasis is placed on the importance of delimiting forms only after a consideration of all carapacial structures. A range chart, based on the examination of material from over 500 localities, is presented to show both vertical (stratigraphic) and horizontal ranges of the species.

IN THE SPRING of 1938, Dr. H. V. Howe called the writers' attention to differences between certain alate forms commonly referred to the genus *Brachycythere* Alexander (1933) and typical representatives of that genus. Subsequent work has revealed that these alate forms are generically synonymous with other alate forms which have been referred to the genus *Cythereis* (*Pterygocythereis*) Blake (1933). These related forms are herein incorporated in the new genus *Alatacythere*.

Previously described species referable to the genus *Alatacythere* are: (1) *A. alata*, first described as *Cypridina alata* by Bosquet (1847), (2) *A. lemnicata*, described by Alexander (1934) as *Cythereis* (*Pterygocythereis*) *lemnicata*, and (3) *A. alexanderi*, described by Howe and Law (1936) as *Cythereis* (*Pterygocythereis?*) *alexanderi*.

The writers have examined materials ranging from Midway to upper Miocene in age. In these samples four species of *Alatacythere* (*A. alata*, *A. alexanderi*, *A. frinki*, and *A. lemnicata*) and 10 species of *Brachycythere* (*B.? formosa*, *B.? foraminosa*,[1] *B. marylandrica*, *B. plena*, *B. martini*, *B. nanafaliana*, *B. jessupensis*, *B. russelli*, *B. bernardi*, and *B. watervalleyensis*) were found.

The specific and generic descriptions have been made as detailed as possible without undue restriction of the species. In most cases, no single carapacial structure has been used in separation of the species, as the usual result of this seems to be a hairline allocation of forms. For example, the writers found themselves attempting to differentiate five or six species of *Brachycythere* in the Claiborne Eocene when actually there seem to be only three (*B. martini*, *B. russelli*, and *B. watervalleyensis*). Only when the numerous finer details of carapacial structure were examined did the correct separation become apparent.

Howe and Chambers (1935) figured *B. watervalleyensis* from the Jackson Eocene of Louisiana. Examination of type specimens shows that figure 4, plate 3 is the same as *B. russelli* Howe and Lea (1936). Figures 1, 2, 3, 5, and 6 of plate 3, figure 1 of plate 4, and figure 7 of plate 6 of Howe and Chambers (1936) are of specimens of *B. watervalleyensis*.

The genus *Alatacythere* is proposed to include certain species of ostracoda previously assigned to the genera *Brachycythere* and *Cythereis* (*Pterygocythereis*). *A. alexanderi* (Howe and Law) is designated as the genotype. Species here assigned to the new genus are unique in that they possess some of the distinctive features of both genera, namely, the hinge structure of *Brachycythere* and the well developed ala of *Cythereis* (*Pterygocythereis*). *Alatacythere* differs from *Brachycythere* in having fewer radial pore canals, especially on the anterior end; in the extreme prominence of the ala; in the muscle scar pattern; in the possession of a usually distinct alial canal with attached radial pore canals; in the ornamentation of the margin of the carapace, and in general shape.

The genus differs from *Cythereis* (*Pterygocythereis*) in general form and shape; in having a single, large prominent alial process

[1] Queries are those of present writers.

with a single lateral spine on each valve; in a greater number and different arrangement of muscle scars; in possession of a *Brachycythere*-like hinge, and in a larger and heavier carapace. When placed together, the only similarity between *Alatacythere* and *Pterygocythereis* is in the mutual possession of alae.

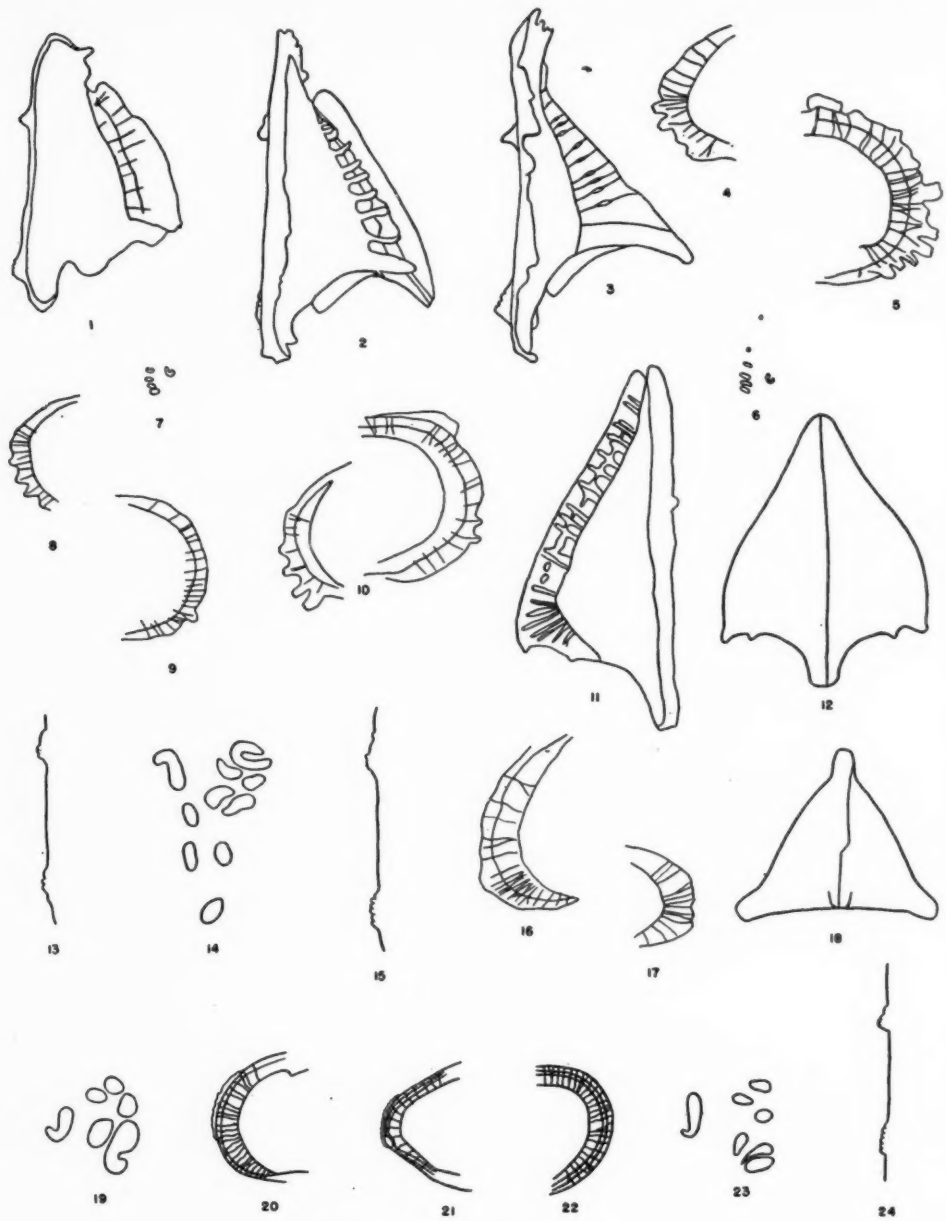
The majority of species of *Brachycythere* appear to possess from 25 to 30 radial pore canals on the anterior end and from 10 to 15 on the posterior end. The canals are frequently anastomosing and usually exhibit a bulbous swelling near the margin of the carapace. Frequently the anterior and posterior teeth and sockets are crenulate. The alae of species of *Brachcythere* tend to be low and elongated. The muscle scar pattern consists of a group of four to six scars anterior to which are one or two other scars. Alial canals are noticeable in a few species but are always poorly developed. The anterior and posterior ends frequently bear from one to 15 spines. Most species tend to be ovate in outline, somewhat inflated anteriorly, and are commonly highest at or slightly anterior to the middle.

In contrast, species of *Alatacythere* normally possess from five to 10 radial pore canals on the posterior end and from 10 to 20 on the anterior end. The canals usually do not anastomose, usually are straight or fairly so, and only rarely exhibit bulbous swellings. The posterior tooth of the right valve and the posterior socket of the left valve are usually distinctly crenulate. The anterior teeth and sockets of the right and left valves are also usually crenulate as are the bars and grooves between the anterior and posterior teeth and sockets. The hinge area is, in proportion to the size of the carapace, distinctly longer than that of *Brachycythere*. The alae of *Alatacythere* are very prominent, smooth, are all pointed, bear only a single lateral spine, and slope gradually upward from near the antero-ventral angle. The muscle scar pattern consists of five to 10 scars arranged roughly into two or three separate groups. The alial canals are usually quite conspicuous as are the radial pore canals attached to them. Both spines and plate-like flanges are present on the anterior and posterior ends of well preserved specimens. The spines and flanges may occur in either single or double rows and may extend along either the dorsal or ventral margins, in addition to the anterior and posterior ends. The carapace is distinctly elongate, roughly quadrate, highest ventral and posterior to the middle, and usually somewhat flattened anteriorly.

The carapacial outlines of *Alatacythere* are, in general, more rounded than are those of *Cythereis* (*Pterygocythereis*); the alae are larger and more pronounced. *Alatacythere* hinges are similar to *Brachycythere* hinges while the *Cythereis* (*Pterygocythereis*) hinges are similar to those of *Cythereis*. The *Alatacythere* muscle scar pattern possesses affinities to both the *Brachycythere* and the *Cythereis* pattern. Table I presents a tabular summary of the outstanding characteristics of the known species of *Alatacythere*.

The genus *Alatacythere* seems to represent a phylogerontic genus, probably derived from a pre-Upper Cretaceous alate ostracod. Several species of *Alatacythere* have been observed in Cretaceous materials but are not treated in the present paper. *A. alata*, the simplest and least ornamented of the known species is likewise the longest lived. With the appearance of more complex ornamentation, the geologic span of the species seems to decrease; their value as stratigraphic markers thereby increases.

Zonation and range.—Zonation of groups and even of certain formations on the basis of species of *Alatacythere* and *Brachycythere* seems quite possible. The Midway contains a distinct assemblage. *Brachycythere* (?) *formosa*, *B.* (?) *foraminosa*, and *B. marylandrica* are restricted to beds of this age. The Sabine or Wilcox is marked by the distinctive forms described by Howe and Garrett, *Brachycythere nanafaliana* and *B. jessupensis*. *Brachycythere plena* ranges throughout the Midway and Sabine or Wilcox. The Claiborne, partially because of the greater number of samples available from these beds, contains the most distinctive assemblage of species. *Brachycythere bernardi* and *Alatacythere frinki* are restricted to sediments of Claiborne age. *Brachycythere bernardi*, insofar as the writers have been able to ascertain, is restricted to the greensand portion of the Cane River of Louisiana and to the Weches of Texas. In addition, *Alatacythere lemnicata*, *A. alata*, *Brachycythere martini*, *B. russelli*, and *B. watervalleyensis* are present



EXPLANATION TO TEXT FIGURE 1

FIGS. *1, 7, 8, 9—Alatacythere frinki* Murray and Hussey, n. sp. Paratype, slide no. 2725. *1*, ×43, dorsal outline of right valve. *7*, ×40, exterior view of muscle scars of right valve. *8*, ×43, exterior view of radial pore canals, posterior end of right valve. *9*, ×43, exterior view of radial pore canals, anterior end of right valve. (p. 173)

2, 10—Alatacythere alexanderi (Howe and Law). Hypotype, slide no. 2738. *2*, ×43, dorsal outline of right valve. *10*, ×43, exterior view of radial pore canals, left valve. (p. 171)

3–6—Alatacythere lemnicata (Alexander). Hypotype, slide no. 2727. *3*, ×00, dorsal outline of

TABLE 1.—TABULAR SUMMARY OF OUTSTANDING CHARACTERISTICS OF SPECIES OF *Alatacythere*

		alexanderi	*lemnicata*	*alata*	*frinki*
Ala	Spine	Curved, very strong.	Curved, strong. Extends to anterior end.	Straight, ala extends to anterior margin.	Weakly developed, straight, apex ⅔ of way from anterior to posterior end.
	Alial Canal	Strongly developed.	Weakly developed.	Strongly developed.	Weakly developed.
Ornamentation	Anterior end	Double row of spines or plate-like flanges on anterior end; about four flanges near antero-dorsal angle.	About twelve to fifteen blunt spines or plate-like flanges arranged in single row; about four plate-like flanges near antero-dorsal angle; row of beads behind spines.	Anterior ornamentation, if present, weakly developed.	Single row of upright, rounded spines.
	Posterior end	Four to six blunt or elongate spines.	Four to six blunt or elongate spines.	Three to four spines.	About seven spines.

in Claiborne samples. *Alatacythere lemnicata* has also been found in Midway samples but has not been found in Sabine or Wilcox materials. Species present in the Jackson are *Brachycythere martini*, *B. russelli*, *B. watervalleyensis*, *Alatacythere alata*, and *A. alexanderi*. The same species are known from the Oligocene. No representatives of either genus are known from sediments of the Gulf Coastal region that are younger than Oligocene in age.

The accompanying chart shows the ranges of the various Gulf Coast species of the two genera as determined to March 1, 1940. In preparation of the chart, materials from over five hundred localities from Maryland to Mexico were examined. Only diagnostic and type localities have been used in compiling the final check list. All samples, unless indicated, are from the surface.

Horizontal and vertical ranges of the species are given at the end of each specific description.

ACKNOWLEDGMENTS

Dr. H. V. Howe suggested compilation of these data. In addition, he gave freely of his time and materials during preparation and

right valve. *4*, ×43, exterior view of radial pore canals, posterior end of right valve. *5*, ×43, exterior view of radial pore canals, anterior end of right valve. *6*, ×43, exterior view of muscle scars of right valve. (p. 173)

11–18—*Alatacythere alata* (Bosquet). *11*, dorsal outline of left valve, hypotype, slide no. 2723. *12*, ×43, dorsal outline of entire carapace, hypotype, slide no. 2722. *13*, ×43, hinge outline of right valve, hypotype, slide no. 2723. *14*, ×175, exterior view of muscle scars of right valve, hypotype, slide no. 2723. *15*, ×43, hinge outline of right valve, hypotype, slide no. 2721. *16*, ×43, exterior view of radial pore canals, anterior end of left valve, hypotype, slide no. 2723. *17*, ×43, exterior view of radial pore canals, posterior end of left valve, hypotype, slide no. 2723. *18*, ×43, posterior end view of entire carapace, hypotype, slide no. 2722. (p. 171)

19–24—*Brachycythere russelli* Howe and Law. *19*, ×110, interior view of muscle scars of right valve, hypotype, slide no. 2731. *20*, ×43, interior view of radial pore canals, anterior end of right valve, hypotype, slide no. 2728. *21*, ×43, interior view of radial pore canals, posterior end of right valve, hypotype, slide no. 2731. *22*, ×43, interior view of radial pore canals, anterior end of right valve, hypotype, slide no. 2731. *23*, ×110, interior view of muscle scars of right valve, hypotype, slide no. 2728. *24*, ×43, hinge outline of right valve, hypotype, slide no. 2732. (p. 178)

TABLE 2.—RANGE OF SPECIES

Group	Midway		Wilcox or Sabine			Claiborne												Jackson							Vicksburg			
State	Tex.	Ark.	La.	Ala.	La.	Ala.	Md.	Tex.								La.												
Formation	Kincaid	Midway	Midway	Clayton	Nanafalia	Wilcox	Mansfield[1]	Naheola	Sucarnoochee	Clayton	Midway	Midway	Aquia	Hatchitigbee	Bashi-Woods Bluff	Tuscahoma	Nanafalia	Wilcox	Mansfield[1]	Naheola	Sucarnoochee	Clayton	Midway	Midway	Aquia	Hatchitigbee	Bashi-Woods Bluff	Tuscahoma	Nanafalia
Brachycythere formosa		×	×																									
B. foraminosa																												
B. marylandrica		×											×															
B. plena																												
B. nanafaliana																												
B. jessupensis																												
B. martini																												
B. russelli																												
B. bernardi																												
B. watervalleyensis																												
Alatacythere lemniscata																												
A. frinki																												
A. alata																												
A. alexanderi																												
Number of samples	3	4	1	1	1	15	18	1	1	1	1w[1]	1	2	1	1	2	1	1	1	1	1	2	2	4	2	2	6	2

Group	Claiborne														Jackson														Vicksburg			
State	Tex.					La.									La.			Miss.				Ala.	Fla.	S.C.	La.			Miss.			Ala.	Fla.
Formation	Queen City	Wecheș	Stone City	Sparta	Crockett	Yegua	Cane River	Sparta	Cook Mountain	Cockfield	Lisbon	Gosport	McBean	Guayabal	Moodys Branch	Yazoo	Danville Landing	Moodys Branch	Yazoo	Cocoa Sand (Cooke)	Cocoa Sand (Cushman)	Yazoo	Ocala	Cooper Marl	Byram	Red Bluff	Marianna	Byram	Marianna	Marianna
Brachycythere formosa																															
B. foraminosa																															
B. marylandrica																															
B. plena																															
B. nanafaliana																															
B. jessupensis																															
B. martini																															
B. russelli																															
B. bernardi																															
B. watervalleyensis																															
Alatacythere lemniscata																															
A. frinki																															
A. alata																															
A. alexanderi																															
Number of samples	2	4	2	2	6	2	175	1	50	2	3	3	2	2	14	1	10	6	3	6	3	2	2	3	7	8	5	14	2	2

[1] w—Sample from well core.
[2] See Murray (1941) and LeBlanc and Barry (1941).

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Type specimens have been deposited in the Henry V. Howe collection, Louisiana State University, University, Louisiana, and in the Stanford University Paleontological Type Collection, Stanford University, California. Type numbers, unless otherwise specified, refer to specimens deposited at Louisiana State University.

All figures of plates 27 and 28, and pen and ink drawings of the species of *Brachycythere* were made by the senior author. Pen and ink drawings of the species of *Alatacythere* were made by the junior author.

SYSTEMATIC DESCRIPTIONS

Order OSTRACODA Latreille
Suborder PODOCOPA G. O. Sars
Family CYTHERIDAE Baird, 1850
Genus ALATACYTHERE Murray and Hussey, n. gen.

Genotype: *Alatacythere alexanderi* (Howe and Law), 1936.

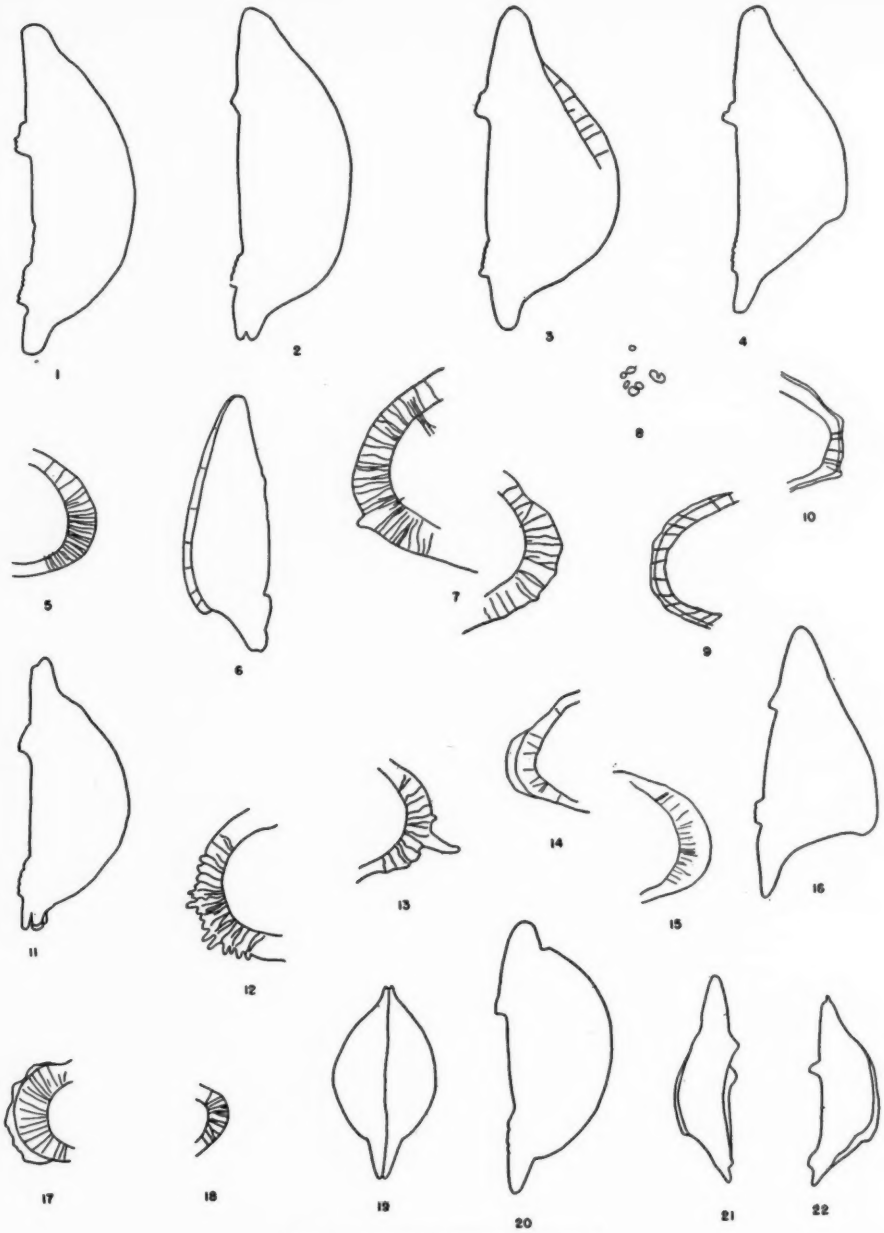
In side view oblong ovate to subquadrate, dorsal margin straight to slightly concave, ventral margin sinuous to slightly convex. Dorsal and ventral margins converge slightly towards posterior end. Anterior end broadly and obliquely rounded, bordered by a thin keel; spines or blade-like plates usually present. Posterior end narrower than anterior end; block-U-shaped, angular or rounded; bears either spines or blade-like plates. Dorsal margin often spinous or keeled. Left valve larger than right, overlapping strongly along entire dorsal margin, tending to overlap slightly along posterior end and along ventral margin. Surface smooth to finely granulose with large widely spaced normal pore canals. Broad low tubercle near anterodorsal cardinal angle usually present.

Carapace triangular in end view or transverse section. Ventral surface slightly compressed, nearly flat, and broad. Strong alate process developed on ventral lateral edge of the valve. Ala highest near posterior end, terminating in a strong spine. Ala, if keeled, usually with a well developed alial canal and attached radial pore canals.

Hinge consists in right valve of an anterior, S-shaped, slightly crenulate tooth posterior to which is a deep socket. A long, straight, finely crenulate groove extends backward from this socket. Posterior to the groove is an elongate, slightly arcuate, very strong, crenulate tooth. Eye spot just beneath anterior portion of anterior tooth. In left valve, corresponding to the anterior tooth and postjacent socket of the right valve, is an anterior, somewhat S-shaped, slightly crenulate socket, immediately posterior to which is a strong, knob-like tooth. Extending backward from this to an elongate, arcuate, crenulate socket is a finely crenulate groove, the groove ending just anterior and dorsal to the posterior socket. Into this groove fits the raised, dorsal margin of the right valve.

Muscle scars are situated anterior to middle of the carapace and consist of either two or three separate groups.

Deepest portion of valve posterior and ventral to middle, corresponding to position of ala on exterior. Marginal zones moderately narrow, radial pore canals about 10 to 20 in number on anterior end and about one-half that number on posterior end, moderately straight and simple, bifurcating at times. Interiorly, marginal areas broad,



EXPLANATION TO TEXT FIGURE 2

FIGS. *1*—*Brachycythere russelli* Howe and Law. ×43, dorsal outline of right valve, hypotype, slide no. 2728. (p. 178)

2—*Brachycythere nanafaliana* Howe and Pyeatt. ×43, dorsal outline of right valve, syntype, slide no. 265. (p. 180)

3, *7*—*Brachycythere plena* Alexander. Topotype, slide no. 2742. *3*, ×43 dorsal outline of right valve. *7*, ×43, exterior view of radial pore canals, anterior and posterior ends. (p. 176)

4, *8*, *9*, *10*—*Brachycythere martini* Murray and Hussey, n. sp. *4*, ×43, dorsal outline of right valve, hypotype, slide no. 2733. *8*, ×43, interior view of muscle scars, left valve, paratype,

line of concrescence and inner margin coinciding throughout.

ALATACYTHERE ALEXANDERI
(Howe and Law)

Plate 27, figures 10, 11; text figure 1, figures 2, 10

Cythereis (Pterygocythereis?) alexanderi HOWE and LAW, *1936*, Louisiana Dept. Conservation, Geol. Bull. 4, pp. 42, 43, pl. IV, fig. 23, pl. V, fig. 5.

Carapace large, fragile, strongly alate; in side view elongate, ovate. Dorsal margin nearly straight, obscured by a series of thin, projecting, blade-like plates; ventral margin sinuous, obscured by projecting ala. Anterior end broadly rounded, bears a double row of flattened spines. Posterior margin narrower than anterior margin, rounded, with three or more flattened or rounded spines. Central portion of carapace smooth, usually translucent or transparent. Muscle scar pattern consists of a group of three scars above a vertical row of four scars. In front of the ventral scar of the row is another scar. Interiorly, the valves are deepest near the ventral margin. Marginal areas are broad. Radial pore canals about 15 in number on anterior end, and about eight in number around posterior end. The hinge is typical of the genus.

Dimensions.—Left valve, hypotype slide no. 2737: length, 1.05 mm.; height, 1.60 mm.

Remarks.—The species is very similar to *A. lemnicata* Alexander from the Midway of Texas and Claiborne of Louisiana and is probably evolved from that form. *A. alexanderi* differs from *A. lemnicata*, however, in possessing a double instead of a single row of spines around the anterior margin and in the absence of a row of low rounded beads just behind the base of the spines. The culminating spine of the ala of *A. lemnicata* is more erect and less strongly developed than is that of *A. alexanderi.*

Occurrence.—*Alatacythere alexanderi* ranges throughout the Vicksburg and is present in the Cooper Marl (Jackson Eocene) of South Carolina. No representatives of the species were found in the Jackson Eocene materials of the Gulf Coast. On the surface, the species is known from Louisiana, Mississippi, Florida, and South Carolina.

Figured specimens are from the lower part of the *Balanophyllia* bed near the base of the Red Bluff Group of the Oligocene in approximately the center of the NE. ¼, sec. 28, T. 10 N., R. 7 W., Wayne County, Mississippi, on the east bank of Chickasawhay River, 250 feet west of Hiwannee Railway station. Elevation approximately 155 feet. Collector, H. V. Howe, 1934.

ALATACYTHERE ALATA (Bosquet)

Plate 27, figure 13, 16–18; text figure 1, figures 11–18

Cypridina alata BOSQUET, *1847*, Soc. royale sci. Liege Mém., vol. 4, p. 369, pl. 4, figs. 1a-d.
Cythereis alata, JONES, *1849*, Paleontogr. Soc. London, p. 36.
Cythereis alata BOSQUET, in Staring, *1860*, De bodem van Nederland, 2 dl., p. 362.
Cythereis alata, BOSQUET, in Ubaghs, *1879*, Description géologique et paleontologique du Sol Limbourg, p. 199.
Cyther pteron alatum JONES and HINDE, *1889*, Palaeontogr. Soc. London, p. 34.

slide no. 2735. *9*, ×43, exterior view of radial pore canals, anterior end of left valve, paratype, slide no. 2735. *10*, ×43, exterior view of radial pore canals, posterior end of left valve paratype, slide no. 2735. (p. 177)

5, 6—Brachycythere watervalleyensis Howe and Chambers. Paratype, slide no. 1125. *5*, ×43, interior view of radial pore canals, anterior end of left valve. *6*, ×43, dorsal outline of left valve. (p. 179)

11–13—Brachycythere marylandrica (Ulrich). Hypotype, slide no. 2741. *11*, ×43, dorsal outline of right valve. *12*, ×43, exterior view of radial pore canals, anterior end of left valve. *13*, ×43, exterior view of radial pore canals, posterior end of left valve. (p. 174)

14–16—Brachycythere bernardi Murray and Hussey, n. sp. Syntype, slide no. 2734. *14*, ×43, exterior view of radial pore canals, posterior end of right valve. *15*, ×43, exterior view of radial pore canals, anterior end of right valve. *16*, ×43, dorsal outline of right valve. (p. 176)

17, 18, 21, 22—Brachycythere? formosa Alexander. Hypotype, slide 2739. *17*, ×55, interior view of radial pore canals, anterior end of right valve. *18*, ×55, interior view of radial pore canals, posterior end of right valve. *21*, ×55, dorsal outline of left valve. *22*, ×55, dorsal outline of right valve. (p. 175)

19—Brachycythere? foraminosa Alexander. ×43, dorsal outline of entire specimen, holotype, slide no. 0-3135.1, J. A. Alexander collection. (p. 175)

20—Brachycythere jessupensis Howe and Garrett. ×43, dorsal outline of right valve, syntype, slide no. 262. (p. 180)

Brachycythere alata (BOSQUET), in Van Veen, *1935*, Natuurhist. Maandbl. Orgaan van het Natuurh. Genootschap in Limburg. Nos. 2, 3, 4 en 5, 28 Febr., 29 Maart, 26 April en 31 Mei, p. 6, pl. 3, figs. 8–12.

Carapace large, in lateral view oblong ovate to subquadrate, strongly alate. Dorsal margin straight to very slightly concave. Ventral margin broadly sinuous. Anterior end broadly rounded, bordered by a keel. Posterior end broadly rounded to bluntly caudate, possessing three to four spines which are strongest ventrally. Beneath the spines is a thin, fragile, somewhat irregular keel. Carapace approximately twice as long as high. Exterior smooth with large, widely spaced, pore canals. Prominent ala present on ventral lateral edge of valves. Carapace widest posterior and ventral to middle, sloping gently toward anterior margin, abruptly toward posterior end. Ala surmounted by a fairly long, heavy spine inclined posteriorly. Secondary spine developed on posterior alial slope. Fifteen to 20 radial pore canals on ala connected by an alial canal extending the entire length of the ala.

In interior view, marginal areas relatively narrow. Inner margin and line of concrescence coincide throughout. Radial pore canals 12 to 14 in number on posterior and anterior ends. Deepest portion of valve posterior and ventral to middle, corresponding to position of ala on exterior. Both valves possess a thin ridge on anterior, ventral, and posterior margins. The ridge of the right valve fits into a similarly located groove of the left valve. Hinge typical of genus.

Dimensions.—Right valve, hypotype slide no. 2720: length, 1.05 mm.; height, 1.51 mm.; left valve, hypotype slide no. 2723: length, 1.15 mm.; width, 0.69 mm.

Remarks.—Alexander (1933) reports the presence of *A. alata* in the Navarro and upper Taylor of Texas and the Saratoga chalk of Arkansas. Moreman (1927) reports it from the Eagle Ford of Texas. The writers find that *A. alata* is present in the Cook Mountain of Louisiana and in the Weches of Texas. The Claiborne forms are so similar to homeotype specimens of *A. alata* from the Maestrichtian of Europe that absolutely no doubt remains as to their correct identity. Alexander's *Alatacythere alata*, however, does not seem to be the same as the European form. Examination of numerous samples of Cretaceous age reveals no form referable to *A. alata*. Alate forms present in the Cretaceous are not the same as homeotype specimens of *A. alata* from the Maestrichtian of Europe, nor are they the same as the Claiborne forms which are identical with the Maestrichtian species. The writers interpret this to mean that *A. alata* was a European species during Cretaceous times. During Lower Tertiary times (Midway and Sabine or Wilcox equivalents), the species migrated to North America, appearing in the Gulf Coast in Claiborne (Weches) times. The Cretaceous form described by Alexander must therefore be referred to another species.

Miss J. E. Van Veen (1934) working independently and prior to our work, reached the conclusion that Alexander's species was not the same as the European form. She says,

> The ostracode which is described by Alexander (1929, 1933) as *Brachycythere alata* and of which he gives figures of remains of the female, we do not regard as identical with ours. From the figures of Bosquet, Alexander, and ourselves, it follows, namely: that the carapace of our ostracode is posteriorly much lower than that of the American one. This is very clearly perceptible, especially in the case of the left valve.

The writers' work substantiates that of Miss Van Veen.

Occurrence.—*A. alata* ranges vertically from the Claiborne (Weches) to the Vicksburg (Marianna). Future work may extend its range in the Gulf Coast. In Europe its known range is Upper Cretaceous. On the surface the form is known from Texas (Weches), Louisiana (Cane River and Cook Mountain), Mississippi (Yazoo and Cocoa Sand of Cushman), and Florida (Marianna).

Figured specimens are from (1) type Milam's section on scarp on southwest side of Antoine Creek in SW ¼, NE ¼, sec. 17, T. 13 N., R. 3 W., Winn Parish, Louisiana. (Hypotype slide no. 2723.) Collector, J. Huner, Jr.; (2) Cook Mountain formation, in ditch leading to creek on south side of lower Dodson road in Winn Parish, Louisiana, in NE ¼, SW ¼, SW ¼, sec. 28, T. 13 N., R. 3 W., upper 2 feet of 12 foot bed. (Hypotype slide no. 2720.) Collector, J. Huner, Jr.; (3) Weches formation, 1000 feet west of

bridge at Smithville, Texas, 10 feet above low water level. (Hypotype slide no. 2722.) Collector, R. R. Copeland, Jr.; and, (4) Type Milams (Cook Mountain) from scarp on SW side of Antoine Creek, SW ¼, NE ¼, sec. 17, T. 13 N., R. 3 W., Winn Parish, Louisiana, J. Huner, Jr., collector. Hypotype slide no. 2721.

ALATACYTHERE FRINKI Murray and Hussey, n. sp.
Plate 27, figures 14, 15; text figure 1, figures 1, 7, 8, 9

Carapace large, fragile, strongly alate. In side view subovate, dorsal and ventral margins nearly straight. Dorsal margin in well preserved specimens partially obscured by a series of thin, blade-like plates. Ventral margin largely obscured by the strongly produced ala. Ala thin, begins posterior to the anterior margin, widest posterior and ventral to middle, with alial and radial pore canals. Anterior end of carapace broadly rounded and studded with a row of obliquely upright, round, short spines approximately twelve in number, under which is a row of very fragile blade-like plates. Plates present only in well preserved specimens. Posterior end narrower than anterior end, rounded with about six round, obliquely upright spines. Posterior spines stronger than anterior spines. Center of carapace smooth, sufficiently transparent to show muscle scar pattern which consists of a vertical row of four elongate spots with two or more spots dorsal and anterior to the main group. Viewed interiorly, carapace deepest posterior and ventral to the middle. Marginal areas broad, with about 12 to 15 radial pore canals on anterior end and a smaller number on the posterior end. Hinge characteristic of genus.

Dimensions.—Left valve, paratype slide no. 2725: length, 0.92 mm.; height, 0.48 mm.

Remarks.—The species most closely resembles *A. alata* (Bosquet) which ranges from Maestrichter (Cretaceous) to Cook Mountain (Claiborne Eocene) times. It differs from *A. alata*, however, in having a less strongly developed ala, and in that the ala begins posterior to the anterior while the ala of *A. alata* is more or less continuous with the anterior marginal rim. *A. frinki* possesses well developed spines around both anterior and posterior ends in addition to plates on the anterior end. In *A. alata* the spines are either absent or are very weakly developed. The species is named in honor of Mr. John W. Frink, graduate student, School of Geology, University of Cincinnati, Cincinnati, Ohio.

Occurrence.—The species has been found only in the Cook Mountain formation of Louisiana where it is a fairly common form.

Type locality.—Cook Mountain formation. Ditch leading to creek on south side of lower Dodson road in Winn Parish, Louisiana in NE ¼, SW ¼, SW ¼, sec. 28, T. 13 N., R. 3 W., upper 2 feet of 12-foot bed. J. Huner, Jr., collector.

Figured specimens are from: (1) type locality. (Paratype slide no. 2724); (2) Cook Mountain formation. Along C.C.C. tram line road about 2½ miles west of Calvin, from creek crossing road, Winn Parish, Louisiana, in SE ¼, NW ¼, SE ¼, sec. 7, T. 11 N., R. 4 W. (holotype slide no. 2726). Collector, J. Huner, Jr.; (3) Cook Mountain formation. Road cut on southeast side of Louisiana Highway 6 at intersection of Louisiana 6 and road to St. Maurice, Winn Parish, Louisiana, in NW ¼, NW ¼, SE ¼, NE ¼, sec. 20, T. 10 N., R. 5 W., 22 to 23 feet below top of slope. (Paratype slide no. 2725.) Collector, J. Huner, Jr.

ALATACYTHERE LEMNICATA (Alexander)
Plate 27, figures 9, 12; text figure 1, figures 3, 4, 5, 6

Cythereis (*Pterygocythereis*) *lemnicata* ALEXANDER, *1934*, Jour. Paleontology, vol. 8, p. 222, pl. 33, fig. 2; pl. 35, figs. 10, 11.

Carapace large, fragile, oblong quadrate, widest ventral and posterior to middle, strongly alate. Dorsal and ventral margins straight, subparallel. Dorsal margin partially obscured by a series of blade-like plates extending posteriorly from antero-dorsal angle. Ventral margin largely obscured by projecting ala. Anterior end broadly rounded; with a low flat marginal rim, bearing a single row of relatively flat spines with a row of small beads behind them. Posterior end narrower than anterior end, rounded, with long, stout, hollow spines along the lower margin. Ala strongly produced, beginning near antero-ventral angle and culminating in a relatively strongly

curved spine posterior and ventral to middle. Alial canal somewhat poorly developed. Viewed interiorly, marginal areas broad, valves deepest posterior and ventral to middle. Hinge and muscle scar pattern characteristic of genus.

Dimensions.—Right valve, hypotype slide no. 2727: length, 1.1 mm.; height, 0.62 mm.

Remarks.—This species is quite similar to *A. alexanderi* (Howe and Law), differing from it, however, in possession of a single instead of a double row of spines around anterior margin and in having a row of low rounded beads along the flattened anterior margin. The culminating spine of the ala of *A. lemnicata* is more erect and less strongly developed than is that of *A. alexanderi.*

Occurrence.—Alexander (1934) reports this species from the Kincaid and Wills Point formation of Texas. The writers have found the species in the Cook Mountain formation of Louisiana and Midway of Arkansas. It would seem, then, that *A. lemnicata,* though it has not yet been observed in materials of Sabine or Wilcox age, ranges at least from Kincaid (Midway) times to Cook Mountain (Claiborne) times.

Figured specimens are from the Wills Point Midway along the Colorado River on the Caldwell Ranch in Bastrop Country, Texas, approximately 1–1½ miles along the river east of the Bastrop-Travis County line. (Hypotype slide no. 2727.) Collector, F. E. Turner.

Genus: BRACHYCYTHERE Alexander, 1933

Genotype: *B. sphenoides* (Reuss), 1854

Care should be exercised in separating *Brachycythere* and *Alatacythere* on the basis of hinge structures. Alexander, 1934, writes concerning the hinge structure of *Brachycythere:*

> Hinge structure of right valve consists of a strong, knoblike anterior tooth and postjacent socket, a slight furrow extending the length of the hinge margin, and a compressed, finely serrate posterior tooth. Corresponding to the anterior tooth and postjacent socket of the right valve, the hinge margin of the left valve bears a deep anterior socket, and immediately behind it, a strong knoblike tooth. A strong ridge or bar, which is below and free of the dorsal margin of the shell except at its posterior end, extends posteriorly from this tooth, and joins the dorsal margin of the valve in front of the long, narrow, notched socket which corresponds to the serrate posterior tooth of the right valve.

Detailed study of Tertiary species of *Brachycythere* reveals that Alexander's original description should be somewhat altered. These forms possess, in many cases, strongly crenulate anterior teeth and sockets and crenulate bars and grooves which are, however, usually not as distinct as in *Alatacythere.* The hinge of Tertiary *Brachycytheres* consists in the right valve of an anterior, more or less crenulate, socket. Extending backward from this is a finely crenulate groove bordered dorsally and ventrally by raised areas or bars. Posterior to the groove is an elongate, crenulate, prominent tooth. The anterior socket in the left valve is very slightly crenulate. Posterior to this is a knoblike, clawlike, or elongate tooth which is smooth in most species, crenulate in some. Extending from this groove is a finely crenulate bar bordered dorsally by a groove. Posteriorly there is an elongate, coarsely crenulate socket.

The prominence of the crenulations of the anterior teeth and sockets varies in different species. Likewise, it quite naturally varies in direct proportion to the amount of abrasion to which the specimen has been subjected.

BRACHYCYTHERE MARYLANDRICA (Ulrich)
Plate 27, figures 7, 8; text figure 2, figures 11, 12, 13

Cythere marylandrica ULRICH, *1901,* Maryland Geol. Surv., Eocene Rept., pp. 119, 120, pl. 16, figs. 16–18.

Brachycythere interrasilis ALEXANDER, *1934,* Jour. Paleontology, vol. 8, no. 2, p. 217, pl. 33, fig. 4.

In lateral view, ovate in outline, highest anterior to center, widest posterior and ventral to center. Dorsal and ventral margins arched, hinge areas straight. Anterior end rounded, with about 15 spines on the lateral edge. Posterior end likewise rounded and with two to five spines, narrower than anterior end. Lateral edges of tumid portion of carapace densely punctate. Central tumid portion with strong irregular pits arranged more or less parallel to edges of carapace. Strength of ala varies in different specimens. Hinge typical of genus. Twenty to 25 radial pore canals on anterior end, 10 to 15 on posterior end.

Dimensions.—Left valve, hypotype slide no. 2740: length, 0.88 mm.; height, 0.48 mm.

Remarks and *occurrence.*—Described originally by Ulrich from the Eocene[2] of Maryland, this species was described independently by Alexander from the Midway of Texas. It is a very distinctive species, common at many localities. Within the Gulf Coast Province, the writers have found the species only in materials of Midway Eocene age, where it occurs in both the Kincaid and Wills Point. It is known from the surface in Texas and Maryland but has not as yet been found elsewhere.

The figured specimens are from the Kincaid Midway along the Colorado River on the Caldwell Ranch in Bastrop County, Texas, approximately ½ mi. along the river east of the Bastrop-Travis county line. (Hypotype slide no. 2741.) Collector, F. E. Turner.

BRACHYCYTHERE?[3] FORMOSA Alexander

Plate 27, figures 1, 4; text figure 2, figures 17, 18, 21, 22

Brachycythere formosa ALEXANDER, *1934*, Jour. Paleontology, vol. 8, no. 2, pp. 217, 218, pl. 33, fig. 3.

Carapace in side view oblong ovate, highest at anterior end. Anterior end broadly rounded with a thin marginal keel. Posterior end sub-rounded, compressed. Dorsal margin arched, greatest slope toward posterior end. Ventral margin straight or slightly sinuous. Surface ornamentation consists normally of two or three rather low elongate ridges more or less parallel to the ventral edge of the carapace. The dorsal-most ridge is swollen bulbously near the center of the carapace. Occasionally, widely spaced shallow pits are present on the surface.

Hinge of left valve consists of a posterior, elongate, somewhat denticulate socket, anterior to which is an elongate bar. The anterior end of the bar expands and swells to form an elliptical, somewhat clawlike tooth. Anterior to the tooth is a deep socket. Dorsal to the bar is an elongate groove. Dorsal and somewhat ventral to the anterior tooth the dorsal marginal ridge expands to form a secondary, elongate tooth or node. Marginal areas broad. Muscle scar pattern indistinct. Ten to 15 radial pore canals on anterior end, 5 to 10 on posterior end.

Dimensions.—Left valve, hypotype slide no. 2739: height, 0.34 mm.; length, 0.52 mm.

Remarks and *occurrence.*—This small, somewhat fragile species, is found only in the basal Midway and thereby serves as an excellent marker. The writers questionably refer the species to the genus *Brachycythere* as it possesses none of the characteristic generic features. Though it probably represents a new genus, sufficient specimens are not available for generic description. For this reason, it is questionably included in the present paper within the genus *Brachycythere.*

On the surface this form has been observed from Texas and Arkansas. It was found also in core samples from a well in Bienville Parish, Louisiana.

The figured specimens are from the type locality of the species. Alexander (1934) gives the location of this locality (Station) as:

> Steep bank along east side of tributary running due north into Tehuacana Creek, about 2 miles in a direct line north and slightly west of the center of the town of Mexia, Limestone County (Texas), and one-quarter of a mile west of the railroad. The very compact, gray, fossiliferous clays carrying numerous small corals lies within the Mexia clay member of the Wills Point formation and about 35 feet above the top ledge of the Tehuacana limestone. A few yards north and west of this outcrop along the creek, lignitic Wilcox strata are faulted down against these lower strata of the Wills Point formation.

Hypotype, slide no. 2739.

BRACHYCYTHERE?[4] FORAMINOSA Alexander

Plate 27, figure 3; text figure 2, figure 19

Brachycythere foraminosa ALEXANDER, *1934*, Jour. Paleontology, vol. 8, no. 2, p. 2, pl. 33, fig. 5.

Carapace in side view elongate, subtriangular, highest anterior to middle. Dorsal margin strongly arched to somewhat angularly convex upward, straight along hinge area with steep postero-dorsal slope. Ventral margin nearly straight to sinuous.

[2] Aquia formation: considered by U. S. G. S. to belong in basal portion of Pamunkey Group. The basal portion of the Pamunkey Group is believed by the survey to be Wilcox, the upper portion to be Claiborne (Wilmarth, 1938).

[3] Our own query.

[4] Our own query.

Anterior end rounded with about ten or twelve short spines on each valve. Posterior end pointed, compressed, triangular, with two or three short blunt spines. Viewed dorsally valves are strongly convex. Ventero-lateral edges of valves produced to form low, indistinct alae. Dorsal to the anterior end of ala is a very shallow furrow which disappears anteriorly and posteriorly. Dorsal to this furrow is a slight, nodelike swelling which is situated near center of carapace. External ornamentation consists of small, shallow to deep pits, deepest near center of valve. Ventrally the pits are arranged sub-parallel to margin of carapace.

Dimensions.—Entire carapace, holotype slide no. 3135.1, J. A. Alexander collection: height, 0.37 mm.; length, 0.66 mm.; width, 0.37 mm.

Remarks and *occurrences.*—*B.? foraminosa* Alexander resembles *B.? ledaforma* (Israelsky) in form but differs from it on the basis of a strongly pitted exterior, in greater height in proportion to length, in a more acute posterior end, in a straight instead of a gently convex ventral margin, and in smaller size. As Alexander points out, it is obviously a descendant of *B.? ledaforma* (Israelsky).

The species resembles no known Tertiary form of this genus. It has been observed only in the Littig member of the Kincaid formation of Texas.

The figured specimen (holotype slide no. 3135.1 of Alexander) is from Alexander's (1934) station 22. He gives the location of this station as:

> Shallow gully in a field 200 feet north of the Lone Oak-Greenville Highway, about three miles northwest of Lone Oak, Hunt County (Texas). The Navarro-Kincaid contact is exposed here.

BRACHYCYTHERE PLENA Alexander

Plate 27, figures 2, 5, 6; text figure 2, figures 3, 7

Brachycythere plena ALEXANDER, *1934*, Jour. Paleontology, vol. 8, no. 2, pp. 216, 217, pl. 33, fig. 6.

Carapace in side view oblong ovate, highest near anterior end. Anterior end broadly and obliquely rounded, posterior end narrow, sub-rounded, with about fourteen small spines in left valve. Dorsal margin arched, essentially straight along hinge line. Ventral margin convex. Surface of valve finely punctate with indistinct ala on ventero-lateral edge. Dorsal to anterior end of ala a straight or curved depression is apparent, particularly in right valve. Depression obscure in left valve. Left valve larger than right, overlapping strongly along dorsal margin.

In interior view, marginal areas relatively narrow. Hinge consists in right valve of an anterior, knoblike tooth, posterior to which is a deep, ovate socket. Extending backward is a long narrow groove bordered dorsally and ventrally by bars. The groove gives way near the postero-dorsal angle to an elongate, crenulate tooth. Twenty-five to 30 radial pore canals on anterior end, 15 more or less, on posterior end.

Dimensions.—Right valve, topotype slide no. 2742: length, 0.95 mm.; height, 0.56 mm.

Remarks and *occurrence.*—This species seems to be restricted to the Lower Eocene, having been found by the writers only in Midway and Sabine or Wilcox sediments. *B. plena* is similar to *B. sphenoides* of Alexander, but differs from it in its greater length to height, in its blunter and more rounded posterior end, and in the more pronounced development of the depression dorsal to the anterior end of the ala. This depression equally well serves to differentiate *B. plena* from *B. russelli*, *B. bernardi*, and *B. watervalleyensis*.

The species is known from surface outcrops in Texas, Arkansas, and Alabama. In Texas it occurs in the Wills Point and Kincaid, in Arkansas in the Basal Midway, and in Alabama in the Clayton, Naheola, Nanafalia, Tuscahoma, and Hatchitigbee.

The figured specimens are from the Kincaid formation of the Midway exposed along the Colorado River on the Caldwell Ranch in Bastrop County, Texas, approximately ½ mile east along the river of the Bastrop-Travis county line. Collector, F. E. Turner. Topotype slide no. 2742.

BRACHYCYTHERE BERNARDI Murray and Hussey, n. sp.

Plate 28, figures 7, 9; text figure 2, figures 14, 15, 16

Carapace elongate-ovate, alate, widest ventrally, highest centrally. Dorsal margin broadly convex, ventral margin sinuous.

Anterior end rounded to oblique, posterior end narrower and more oblique, slightly caudate, sloping broadly from ventral margin and steeply from dorsal margin. Left valve larger than right, overlapping strongly along dorsal and ventral margins and anterior end. A prominent tubercle is usually present near antero-dorsal angle. External surface smooth. Normal pore canals small, rather widely spaced. Peripheral margins unornamented except for a thin flange around anterior and posterior ends. Ala quite prominent, begins at anterior end just dorsal to the antero-ventral angle and extends posteriorly, terminating ventral and posterior to the middle of the carapace in a single blunt spine.

In interior view inner margin and line of concrescence coincide throughout. Marginal areas relatively narrow along dorsal and ventral sides but moderately broad around anterior and posterior ends. About 12 to 15 radial pore canals on anterior end, 8 to 10 on posterior end. Canals crooked, sometimes bifurcating.

Hinge consists in right valve of a prominent anterior, somewhat S-shaped, finely crenulate tooth. Posterior and anterior to this are deep, oval sockets, extending back from which is a rather shallow, finely crenulate groove. This is terminated by a strong, coarsely crenulate, elongate, posterior tooth. Dorsal to the crenulate groove is a thin bar which fits into a corresponding groove in the left valve. Both right and left valves possess low rounded ridges around the anterior, dorsal, and ventral margins. The bar of the left valve fits into that of the right. Carapace deepest ventral to middle. About 20 radial pore canals on anterior end, 10 to 15 on posterior end.

Dimensions.—Syntype slide no. 2734; right valve: length, 0.92 mm.; height, 0.52 mm.; complete carapace, length, 0.90 mm.; width, 0.59 mm.

Remarks and *occurrence.*—The species resembles an overgrown *Cytheropteron* but has a definite *Brachycythere* hinge. It is apparently restricted to the greensand portion of the Cane River of Louisiana and to the Weches of Texas. The species is named for Mr. Allen Bernard, Southwestern Louisiana Institute, Lafayette, La.

BRACHYCYTHERE MARTINI Murray and Hussey, n. sp.
Plate 28, figures 6, 10; text figure 2, figures 4, 8, 9, 10

Carapace in lateral view elongate-ovate, alate, thickest at or slightly ventral to the middle, highest near the anterior end. Dorsal margin straight to slightly convex, ventral margin sinuous. Anterior end broadly to obliquely rounded, posterior end semi-rounded, somewhat caudate in outline, sloping gently from ventral margin, steeply from dorsal margin. Left valve larger than right valve, overlapping strongly along anterior and posterior ends, less so along dorsal and ventral margins. A small tubercle is usually present near antero-dorsal angle. External ornamentation consists of large, shallow pits arranged in reticulate pattern on tumid portion of carapace. Peripheral margins free of pits, smooth and shining. Normal pore canals small, rather widely spaced. About three spines, strongest ventrally, present on the posterior end, three to four large spines on anterior end. Irregular, slightly drawn-out flange usually present beneath spines on anterior end. Ala begins at or just dorsal to the antero-ventral angle, extends upward and posteriorly, terminating slightly ventral and posterior to the middle of the carapace in a single blunt spine.

In interior view, inner margin and line of concrescence coincide throughout. Marginal areas relatively narrow, widest on anterior end. About 25 to 30 radial pore canals on anterior end, 12 to 14 on posterior end. Canals crooked, anastomosing, bifurcating, and swollen bulbously near margin of carapace.

Hinge consists in right valve of an anterior, somewhat S-shaped tooth with a more or less pronounced knob on the posterior portion of the tooth. This tooth in some specimens is finely crenulate. Posterior to the tooth is an oval, rather deep socket, extending backward from which is a finely crenulate groove. The groove, which terminates just anterior to a posterior, elongate, coarsely crenulate tooth, is bordered dorsally and ventrally by raised areas or bars, the dorsal bar fitting into a groove in the left valve. Both right and left valves possess low, rounded ridges around the anterior,

ventral, and posterior margins, the ridge of the left valve fitting inside that of the right valve. Carapace deepest just ventral to the middle.

Dimensions.—Entire carapace, syntype slide no. 2730: width, 0.54 mm.; height, 0.50 mm.; length, 0.90 mm.

Remarks.—This very common Claiborne species is easily distinguished on the basis of the shallow, reticulately arranged pits on the tumid portion of the carapace. As far as the writers have been able to determine, this type of ornamentation is characteristic of no other species. Sexual dimorphism is pronounced in this species, with the female being higher and more tumid posteriorly than the male. The posterior slope of the female carapace is greater than that of the male. Stadnichenko (1927) incorrectly applied the name *Cytheropteron virgineum* to this form. The species is named for Mr. James L. Martin, Louisiana Geological Survey, University, La.

Occurrence.—The species is present in both Claiborne and Jackson sediments. Vertically it ranges from the Weches to the very top of the Jackson. Horizontally, it is known from Texas (Weches, "Stone City," Crockett), Louisiana (Cane River, Cook Mountain, Moodys Branch, Danville Landing), Mississippi (Yazoo, Cocoa Sand of Cooke), and Georgia (McBean). The type locality is the left bank of Saline Bayou beneath L. & A. R. R. bridge, sec. 15, T. 9 N., R. 6 W., St. Maurice, Winn Parish, Louisiana. Sample beneath middle of five iron ore ledges. Cook Mountain formation. Collector, H. V. Howe.

Figured specimens are from (1) type locality (syntype slide no. 2736); (2) Cook Mountain formation at Evergreen Crossing of Elm Creek, five miles north of Giddings, Lee County, Texas. A. D. Ellis, Jr., collector (paratype slide no. 2735); (3) Cook Mountain formation, ditch leading to creek on south side of lower Dodson road in Winn Parish, Louisiana, in NE ¼, SW ¼, SW ¼, sec. 28, T. 13 N., R. 3 W., upper two feet of 12-foot bed. J. Huner, Jr., collector (paratype slide no. 2733); (4) Lisbon formation, E. A. Smith's bed 14, Claiborne Bluff, Alabama (paratype slides nos. 2729 and 2730).

Brachycythere russelli Howe and Lea

Plate 28, figures 1, 4, 5, 8; text figure 1, figures 19, 20, 21, 22, 23, 24; text figure 2, figure 1

Brachycythere watervalleyensis Howe and Chambers, *1935*, La. Dept. Cons., Geol. Bull. 5, pl. III, fig. 4 (*not* pl. III, figs. 1, 2, 3, 5, 6; *not* pl. II, fig. 1; *not* pl. VI, fig. 7).

Brachycythere russelli Howe and Lea, *1936*, *in* Howe and Law, 1936, La. Dept. Cons., Geol. Bull. 7, pp. 41, 42, pl. II, figs. 30, 31; pl. III, figs. 23–25.

Carapace in side view oblong ovate, alate. Anterior end obliquely rounded. Posterior end narrowly rounded. Dorsal margin arched, straight along the hinge line. Ventral margin straight to convex downward. Ala low, elongate. Anterior and posterior ends often bear spines. Highest anterior to middle. Surface of valves smooth.

In interior view, deep, with relatively broad marginal areas. Radial pore canals widely spaced, sometimes bifurcating. Muscle scar pattern distinct, consisting of an oblique row of four scars anterior to which are two other scars.

Hinge consists in left valve of a deep, circular, crenulate, anterior socket, posterior to which is a rounded knoblike tooth. A strong bar extends posteriorly to a large, deep, crenulate socket. A deep, often crenulate groove separates the bar from the dorsal margin. Twenty to twenty-five radial pore canals on anterior end, ten to fifteen on posterior end.

Dimensions.—Complete carapace, syntype slide no. 1681: length, 1.00 mm.; height,. 0.57 mm.; thickness, 0.63 mm.

Remarks and *occurrence.*—This species, which is quite abundant at most Vicksburg and Red Bluff Oligocene localities, also occurs in Jackson and Claiborne Eocene materials. It is particularly variable in form in the Claiborne, where it is one of the most common species of *Brachycythere*. Figures 1, 4, 5, and 8 of plate 28 show the extremes in variation in this species. Originally the writers, because of insufficient specimens, believed these to be two different species. Additional work, however, resulted in the discovery of forms intermediate in character between the two extremes. Because of the

imperceptibility of gradation of the forms into one another, even varietal distinction is not believed advisable. The Claiborne Eocene forms are identical with the Oligocene and Jackson Eocene forms, so that the range of the species is from Claiborne Eocene to Vicksburg Oligocene. The greater posterior height and tumidity of the female is interpreted as indication of the sexual dimorphism of the species. Horizontally, the species occurs in Texas (Weches, Crockett), Louisiana (Cane River, Cook Mountain, Moodys Branch, Danville Landing, Byram), Mississippi (Moodys Branch, Yazoo, Cocoa Sand of Cooke and Cushman, Red Bluff, Marianna, Byram), Alabama (Lisbon, Gosport), Florida (Marianna), and Mexico (Guayabal). Figured specimens are from (1) Cane River formation, Urania Oil Field, LaSalle Parish, Louisiana, Louisiana Oil and Refining Company's Tremont No. 1 well, Sec. 30, T. 10 N., R. 2 E., depth, 1506–1508½ feet. (Hypotype slides nos. 2728 and 2732.); and (2) Cook Mountain formation on left bank of Saline Bayou beneath L. & A. R. R. bridge, sec. 15, T. 9 N., R. 6 W., St. Maurice, Winn Parish, Louisiana, sample from beneath middle of five iron ore ledges. (Hypotype slide no. 2731.)

BRACHYCYTHERE WATERVALLEYENSIS Howe and Chambers

Plate 28, figures 2, 3; text figure 2, figures 5, 6

Brachycythere watervalleyensis HOWE AND CHAMBERS, *1935*, Louisiana Dept. Cons., Geol. Bull. 5, pl. II, figs. 1, 2, 3, 5, 6 (*not* fig. 4); pl. IV, fig. 1; pl. VI, fig. 7.

Carapace in side view elongate, ovate; longest ventral to middle, highest anterior to middle, thickest posterior and ventral to middle. Anterior end broadly and obliquely rounded, bearing several short flattened spines. Posterior end narrower, with several short, often blunt, rounded spines. Dorsal margin arched, straight along hinge line. Ventral margin slightly convex to straight. Surface of valve smooth. Ala begins near antero-ventral angle and extends posteriorly almost to posterior end, terminating in a spine.

Interiorly, valves deep with rather broad marginal areas. Line of concrescence and inner margin coincide. Radial pore canals on anterior end long, closely spaced, on posterior end fewer in number.

Hinge of right valve consists of a high, somewhat elongate, often crenulate tooth. Posterior to this is a deep socket. Extending posteriorly from the socket is a narrow, finely crenulate groove just ventral to the dorsal margin. The posterior cardinal tooth is elongate, often crenulate.

Dimensions.—Entire carapace, holotype slide no. 817: length, 0.86 mm.; height, 0.46 mm.; thickness, 0.48 mm.

Remarks and *occurrence.*—This species, abundant at most Jackson Eocene localities, has been recorded at a single Claiborne Eocene (Cook Mountain) locality. Howe and Chambers originally figured six specimens, subsequent examination of which proves that paratype no. 820 (Henry V. Howe Collection, Louisiana State University) belongs to the species *B. russelli*. Young moults of *B. watervalleyensis* differ markedly from adult specimens of the same species in carapacial outlines and in the development and form of the alae. As it is possible to set up a series of specimens grading imperceptibly from the elongate young moult with little or no ala to the more ovoid adult with a distinct and well developed ala, even varietal distinction is believed inadvisable. Additional examination of Claiborne materials may reveal the presence of this species in materials other than Cook Mountain in age. Sexual dimorphism, though not pronounced, is noticeable in many specimens of this species, being exhibited as a greater relative height and posterior tumidity of the female plus a greater posterior slope of the carapace. Horizontally, the species is known from surface samples from Louisiana (Cook Mountain, Moodys Branch, Yazoo, Danville Landing), Mississippi (Moodys Branch, Yazoo, Cocoa Sands of Cooke and Cushman), and Alabama (Yazoo). Figured specimens are from (1) Yazoo Clay, 27 feet below the Cocoa Sand of C. W. Cooke (Alabama, Geol. Survey, Sp. Rept. no. 14, 1926, pp. 274–75), on "Slick" or Keyser Hill, ¼ mile west of Water Valley, Alabama. H. V. Howe, collector. Holotype slide no. 817 and paratype slide no. 1125.

BRACHYCYTHERE NANAFALIANA
Howe and Pyeatt
Plate 28, figures 11, 12; text figure 2, figure 2

Brachycythere nanafaliana HOWE and PYEATT (*in* Howe and Garrett), *1934*, La. Dept. Conservation, Geol. Bull. no. 4, pp. 48–49, pl. III, fig. 18; pl. IV, fis. 1, 3.

Carapace tumid, in side view elongate ovate, thickest posterior to middle, highest anterior to middle. Anterior end broadly and somewhat obliquely rounded. Posterior end narrower, rounded, with three or four spines; postero-dorsal portion indented. Dorsal margin convex upward, straight along hinge line. Ventral margin convex downward to sinuous. Surface ornamentation consists, on tumid portion, of small pits sub-parallel to dorsal and ventral margins. Steep ventral surface adorned with several small ridges parallel to ventral margin. Interiorly, valves deep with moderately broad marginal areas, flanged near middle of ventral margin. Muscle scar pattern and radial pore canals obscure.

Hinge line consists in right valve of a strong, knob-like anterior tooth, posterior to which is a deep socket. Extending backward from the dorsal portion of the socket is a groove, bordered dorsally by a strong dorsal marginal bar and ventrally by a weak bar. The groove is sometimes finely crenulate. A posterior, elongate tooth usually exhibits distinct denticulations. Twenty to twenty-five radial pore canals on anterior end, ten to fifteen on posterior end.

Dimensions.—Right valve, syntype slide no. 265: length, 1.06 mm.; height, 0.58 mm. Left valve, syntype slide no. 264: length, 1.02 mm.; height, 0.60 mm.

Remarks and *occurrence.*—This distinctive species, which seems to be limited to sediments of Wilcox or Sabine age, bears a slight resemblance only to *B. martini.* It differs from this form, however, in having a smaller amount of ornamentation on the anterior and posterior ends, in having a greater number of and deeper pits on the tumid portion of the carapace, and in the absence of a strong ala. Howe and Garrett (1934) report this species from the Nanafalia of Alabama and from their Fort Jessup, Louisiana, locality which they correlate with the type Nanafalia of Alabama.

Figured specimens are from (1) Fort Jessup, Louisiana (syntype slide no. 265). Howe and Garrett give the location of this locality as, " . . . a 45-foot hand-dug well on the place of Mr. I. G. Lee, 1.6 miles southwest of Fort Jessup, Louisiana, on the south side of the Fort Jessup-Many highway." They refer this horizon to the Nanafalia of Alabama. Howe and Garrett, collectors.

BRACHYCYTHERE JESSUPENSIS
Howe and Garrett
Plate 28, figures 13, 14; text figure 2, figure 20

Brachycythere jessupensis HOWE and GARRETT, *1934*, La. Dept. of Conservation, Geol. Bull. 4, pp. 47, 48, pl. III, figs. 14, 16, 17.

Carapace sub-ovate in side view, thickest

EXPLANATION OF PLATE 27

FIGS. *1, 4—Brachycythere? formosa* Alexander. *1*, ×46, exterior view of left valve, hypotype, slide no. 2739, *4*, ×46, hinge of left valve, hypotype, slide no. 2739. (p. 175)

2, 5, 6—Brachycythere plena Alexander. Hypotypes, slide no. 2742. *2*, ×42, exterior view of right valve. *5*, ×42, exterior view of left valve. *6*, ×42, hinge of right valve (p. 176)

3—Brachycythere? foraminosa Alexander, ×36, exterior view of right valve of an entire specimen, holotype, slide no. 0-3135.1 of J. A. Alexander (p. 175)

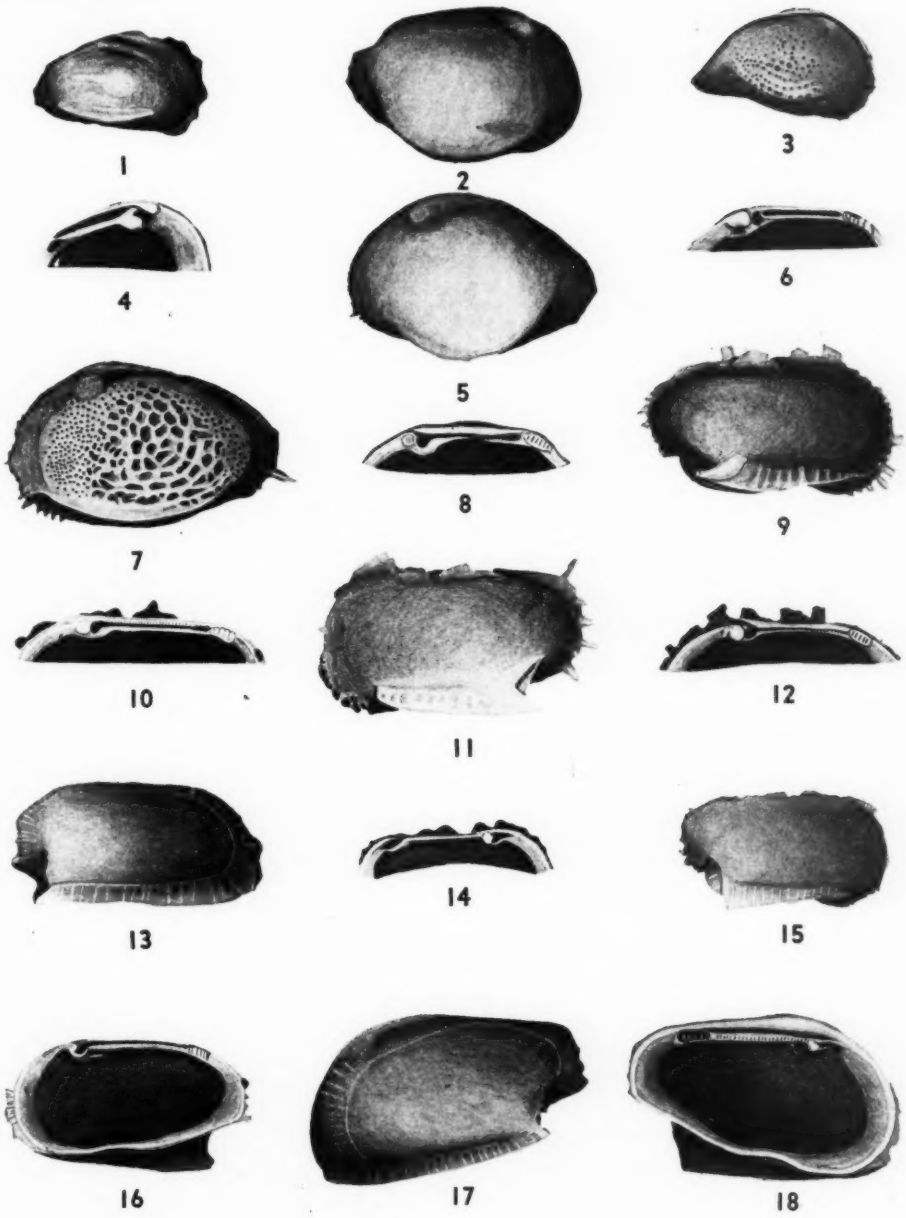
7, 8—Brachycythere marylandrica (Ulrich). Hypotypes, slide no. 2741. *7*, ×42, exterior view of left valve. *8*, ×42, hinge of right valve. (p. 174)

9, 12—Alatacythere lemnicata (Alexander). Hypotypes, slide no. 2726. *9*, ×32, exterior view of right valve. *12*, ×32, hinge of right valve. (p. 173)

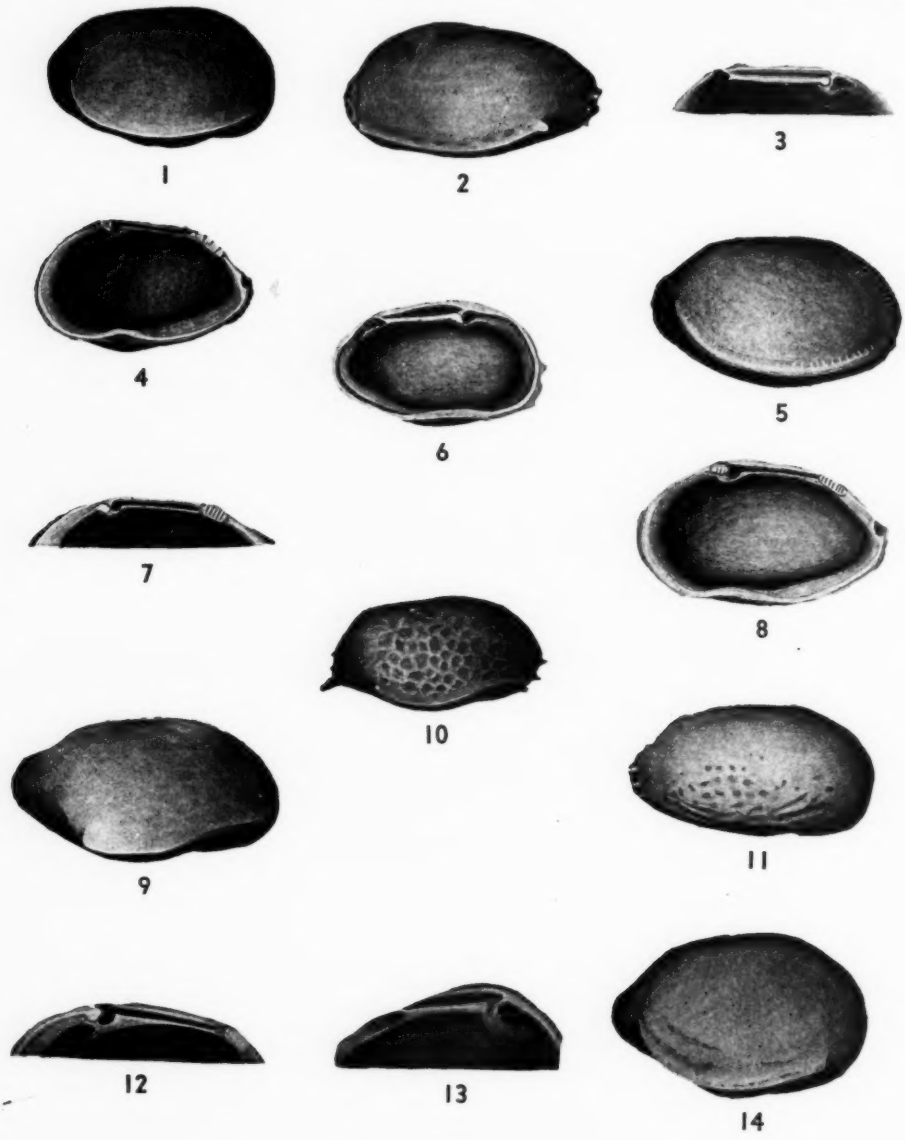
10, 11—Alatacythere alexanderi (Howe and Law). Hypotypes, slide no. 2738. *10*, ×40, hinge of right valve. *11*, ×40, exterior view of left valve. (p. 171)

13, 16–18—Alatacythere alata (Bosquet). *13*, ×32, exterior view of right valve, hypotype, slide no. 2720. *16–18*, hypotypes, slide no. 2723. *16*, ×32, interior view of right valve. *17*, ×32, exterior view of left valve. *18*, ×32, interior view of left valve. (p. 171)

14, 15—Alatacythere frinki Murray and Hussey, n. sp. *14*, ×32, hinge of left valve, paratype, slide no. 2724. *15*, ×32, exterior view of right valve, holotype, slide no. 2726. (p. 173)



Murray and Hussey, Tertiary Ostracodes



Murray and Hussey, Tertiary Ostracodes

posterior to or near the middle, highest anterior to middle. Anterior end broadly rounded, dorsally oblique; posterior end much narrower, sub-acute, dorsal and ventral portions oblique. Dorsal margin arched, straight along hinge line. Ventral margin convex downward to sinuous. Surface generally polished with small widely spaced pits. Ventral edge possesses a strong ala which begins slightly anterior to posterior end and terminates anterior and ventral to middle. Dorsal to and parallel to ala there are two or three low ridges which tend to merge anteriorly.

Interior of valves deep, with thick marginal areas. In each valve, a small flange is present near the middle of the ventral margin. Hinge typical of genus, crenulate.

Dimensions.—Right valve, syntype slide no. 262: length, 0.86 mm.; height, 0.50 mm. Left valve, syntype slide no. 263: length, 0.86 mm.; height, 0.62 mm.

Remarks and *occurrence.*—This form resembles no other described *Brachycythere.* It is known from Fort Jessup, Louisiana (Nanafalia), and from the Nanafalia, Tuscahoma, Bashi-Woods Bluff, and Hatchitigbee of Alabama.

Figured specimens are from Fort Jessup, Louisiana. Howe and Garrett (1934) give the location of this locality as, " . . . a 45-foot hand-dug well on the place of Mr. I. G. Lee, 1.6 miles southwest of Fort Jessup, Louisiana, on the south side of the Fort Jessup-Many highway." They refer the horizon to the Nanafalia of Alabama. Syntype slides nos. 262 and 263. Collectors, Howe and Garrett.

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EXPLANATION OF PLATE 28

FIGS. *1, 4–5, 8—Brachycythere russelli* Howe and Law. *1*, ×42, exterior view of right valve, homeotype, slide no. 2731. *4*, ×42, interior view of right valve, homeotype, slide no. 2731. *5*, ×42, exterior view of right valve, homeotype, slide no. 2732. *8*, ×42, interior view of right valve, homeotype slide no. 2732. (p. 178)

2, 3—Brachycythere watervalleyensis Howe and Chambers. *2*, ×38, exterior view of left valve, holotype, slide no. 817. *3*, ×38, hinge of left valve, paratype, slide no. 1125. (p. 179)

6, 10—Brachycythere martini Murray and Hussey, n. sp. *6*, ×42, interior view of left valve, syntype, slide no. 2733. *10*, ×42, exterior view of right valve, syntype, slide no. 2733. (p. 177)

7, 9—Brachycythere bernardi Murray and Hussey, n. sp. Syntypes slide no. 2734. *7*, hinge of right valve. *9*, exterior view of right valve. (p. 176)

11, 12—Brachycythere nanafaliana Howe and Garrett, *11*, ×32, exterior view of right valve, syntype, slide no. 265. *12*, ×32, hinge of right valve, syntype slide, no. 233. (p. 180)

13, 14—Brachycythere jessupensis Howe and Garrett *13*, ×40, hinge of left valve, syntype, slide no. 263. *14*, ×42, exterior view of right valve, syntype, slide no. 262. (p. 180)

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NOTES ON PACIFIC COAST GALEODEAS

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ABSTRACT—In the taxonomic section *Galeodea meganosensis* Vokes, *G. susanae* Schenck, *G. sutterensis* Dickerson, and *G.* ? n. sp. [*G. petrosa* (Conrad) of Anderson and Hanna, 1925] are assigned to the subgenus *Gomphopages* Gardner. *Galeodea tritubercula* (Weaver), *G. dalli* Dickerson, *G. fax* Tegland, *G. rex* Tegland and *G. apta* Tegland are assigned to the genus *Echinophoria* Sacco. *Galeodea tuberculiformis* Hanna is made the type of the new genus *Coalingodea* Durham. *Galeodea crescentensis* Weaver and Palmer is an anomalous species; lack of adequate material prevents its allocation. In the stratigraphic section *Echinophoria apta* (Tegland) is demonstrated to be younger than *E. rex* (Tegland), and concurrently the upper part of the type Twin Rivers formation is shown to be younger than the fossiliferous part of the type Blakeley formation. *E. dalli* (Dickerson) is distinct from *E. fax* (Tegland).

WHILE WORKING on the Oligocene faunas of Washington, the author has had occasion to collect and examine numerous Galeodeas. Observations at variance with the conclusions of Tegland (1931) were made, leading to a study of all the Galeodeas from the lower Tertiary of the Pacific Coast. The study was divided into two parts, the first taxonomic and the second stratigraphic (Oligocene only). Assistance in the preparation of this manuscript and plates was furnished by the personnel of the Work Projects Administration, Official Project no. 65-1-08-62, unit A-1.

TAXONOMY

Studies on the Cassididae, bearing upon the classification of the Pacific Coast Galeodeas, have been made in America by Dall (1909, pp. 57–69), Schenck (1926), Tegland (1931), and Gardner (1939, pp. 21–28). Important contributions outside America have been made by Finlay (1926, pp. 230–231), Marwick (1931, pp. 103–105), Wrigley (1934), and Finlay and Marwick (1937, pp. 67–68, 107).

The genotype of *Galeodea* Link 1807 is *Buccinum echinophorum* Linné. Two variants are figured here (pl. 29, figs. 1, 3) and Schenck has figured a third (1926, p. 14, fig. 2). Wrigley (1934, pp. 119–120), Dall (1909, pp. 64–65) and Gardner (1939, p. 21) have given diagnoses of the genus but the following features of the genotype have not been stressed. The callus on the inner lip is always large and free from the shell anteriorly. The anterior canal is moderately long and sharply but varyingly recurved, but there is *no notch at the tip* (see text fig. 1). A terminal varix is always present but it is dentate only when heavily developed. When in its early stages, the varix bears but slight or no traces of denticles. The last one or two whorls are somewhat eccentric upon the axis of coiling in the manner of *Distorsio*. The suture is abutting and no "corded" sutural collar is present.

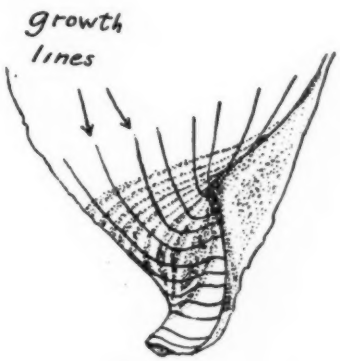


FIG. 1—*Galeodea echinophora* (Linné). Sketch of anterior canal, lateral view, note absence of notch.

Tegland in 1931 (p. 405, footnote 9) noted that there were two "lines" of "Galeodeas" present in the California Eocene but did not attempt revision of them, only noting that one was represented by *Galeodea tritubercula* (Weaver). Recently Gardner (1939, p. 23) proposed a new section of *Galeodea*, *Mambrinia*, designating as type *Cassidaria*

planotecta Meyer and Aldrich (Gardner, 1939, pp. 24–25, pl. 7, figs. 1, 2, 10, 15) and noted that the section occurs in the Meganos and Domengine of the Pacific Coast but did not refer to any species. One of the essential characters cited by Gardner is the "long, slender anterior canal produced in the plane of the aperture but not the axis of the body and spire." Examination of all West Coast species described has shown none with such a canal. *G. sutterensis* Dickerson most nearly approaches this description but the canal is not as long and is slightly recurved from the plane of the aperture (see pl. 29, fig. 2).

Further on (p. 25) in the same work the subgenus *Gomphopages* Gardner is proposed, with *Galeodea* (*Gomphopages*) *turneri* Gardner as type, stating that the subgenus is known only from the subgenotype. The subgenotype in turn is apparently known from a single specimen, inasmuch as it is later noted as "unique." The subgenotype is quite similar to many of the western Eocene Galeodeas except that the nodes are not staggered from one row to the other and that the spire is nearly submerged in the body whorl. *Galeodea susanae* Schenck is nearly identical in configuration except for a slightly higher spire and staggered nodes instead of vertically aligned nodes. However, on page 27 of the same work Gardner notes that there is not sufficient material to be sure that the alignment of nodes is of superspecific value. It seems then that many of the West Coast Eocene species will fit into the subgenus *Gomphopages* Gardner, unless additional material proves that the vertically aligned nodes are of superspecific importance. Species that may be assigned to this subgenus are:

1. *Galeodea* (*Gomphopages*) *meganosensis* Vokes. *1939, Galeodea sutterensis* Dickerson subsp. *meganosensis* Vokes, New York Acad. Sci. Annals vol. 38, p. 151, pl. 19, fig. 18.

This form is raised to specific rank, differing from *G. sutterensis* Dickerson in having but two rows of nodes with a moderately prominent spiral rib between them and in having every fourth fine spiral slightly heavier than the rest.

Horizon: Eocene, Meganos stage.

2. *Galeodea* (*Gomphopages*) *susanae* Schenck. *1926, Galeodea susanae* Schenck, California Univ. Dept. Geol. Sci., Bull. vol. 16, p. 85, pl. 15, figs. 3–7.

Horizon: Eocene, Domengine stage.

3. *Galeodea* (*Gomphopages*) *sutterensis* Dickerson. *1916, Galeodea sutterensis* Dickerson, California Univ. Dept. Geol. Sci., Bull. vol. 9, p. 492, pl. 40, figs. 1, 2.

Horizon: Eocene, Capay stage.

4. *Galeodea* (*Gomphopages*), n. sp.
1925, Galeodea petrosa (Conrad) Anderson and Hanna, California Acad. Sci. Occ. Papers, no. 11, p. 108, pl. 10, figs. 2, 3.
?1855, Stramonita petrosa Conrad, House Doc. 129, Proj. vol. 3, 33rd Cong. 1st Sess., p. 17: App. to Prelim. Geol. Rept. by W. P. Blake.
?1857, Stramonita petrosa Conrad, Pac. R. R. Repts., vol. 5, p. 327, pl. 6, figs. 47, 47a.
Hypotypes: C. A. S. no. 823, U. C. Mus. Pal. no. 12596.

Much confusion has existed around this species. Conrad's types are internal molds from a clay boulder "that had been washed down from the hills at the head of the Tulare valley, about 20 miles west of the Canada de los Uvas." It is nearly impossible to compare them with the type Tejon *Galeodea*, it might from its outline be any of several different species. Schenck (1926, p. 82) and Tegland (1931, pp. 408–409) have confused the Tejon species with *Echinophoria tritubercu-lata* (Weaver) from the Cowlitz Eocene of Washington. It may readily be distinguished from the Washington species by absence of the "corded" suture, the ridge on the anterior canal, and the longer body whorl present on the latter. From *Galeodea* (*Gomphopages*) *sutterensis* Dickerson it may be distinguished by its larger size and greater number of nodes on the body whorl. (Hypotype no. 12596 has a diameter of 40 mm. across the body whorl with 11 nodes present.)

Horizon: Eocene, Tejon stage.

Sacco (1890, pp. 503–504) described *Echinophoria* as a subgenus of *Cassis* with *Buccinum intermedium* Brocchi as the type. Cossmann (1903, pp. 125–127) rejected it for several reasons, one of which was that it was too near *Echinophora* Leske (1778). Finlay (1926, pp. 230–231) established the genus *Euspinacassis* with *Euspinacassis pollens* Finlay from the Oligocene (*fide* Marwick, 1931, p. 103) of New Zealand as the genotype, at the same time recognizing its close relationship to *Echinophoria* Sacco which he considered as preoccupied (apparently referring to *Echinophora* Leske). Rutsch later (1931) considered that *Euspinacassis* Finlay is a synonym of *Echino-*

phoria Sacco and that *Echinophoria* Sacco is not preoccupied by *Echinophora* Leske (1778), because Leske did not use the name in a generic sense. However, in 1825, Latreille in his "Familles Naturelles Du Regne Animal" used *Echinophora* as a genus under his family Cassidites. As used by Latreille it is a synonym of *Galeodea* Link. Nevertheless according to the rules of nomenclature as commonly interpreted in America the addition of the "i" in the ending is sufficient to separate *Echinophoria* Sacco, 1890 from *Echinophora* Latreille, 1825.

The text figures of Rutsch (*loc. cit.*) shows that *Euspinacassis* and *Echinophoria* are extremely closely related and should be referred to the same generic category. Rutsch considered *Echinophoria* as a subgenus of *Phalium* Link, 1807. However, *Cassis glauca* Linneaus, the genotype of *Phalium* lacks the ridge in front of the columellar fassiole, has several spire varices and a nearly smooth body whorl, characters not found on *Buccinum intermedium* Brocchi, the genotype of *Echinophoria*. In view of these differences *Echinophoria* is here considered as a distinct genus.

Comparison of specimens of *Galeodea trituberculata* (Weaver) with *Buccinum intermedium* Brocchi shows that they are closely related and undoubtedly should be referred to the same genus. The body whorl of Weaver's species is not quite so high, but the type of noding, the fine spirals, the sutural collar, the ridge in front of the columellar fasciole, the shape of the callus on the inner lip, the reflected outer lip, the most prominent lirations on the outer lip being anterior (instead of posterior as in *Galeodea*), and the anterior columellar plaits show the extremely close relationship of these two species. Therefore *Galeodea trituberculata* (Weaver) is assigned to the genus *Echinophoria* Sacco. Essential characters of the genus may be taken as those listed above as common to the two species. Differences from *Gaeodea* Link are the notch in the anterior canal (see text fig. 2), the ridge anterior to the fasciole, the "corded" sutural collar, and the most persistent denticles on the outer lip being anterior instead of posterior. "*Galeodea*" *trituberculata* (Weaver) (pl. 29, fig. 10) is the most typical of the Pacific Coast representatives of the genus. All the Oligocene species commonly referred to *Galeodea* also belong to this genus. When one examines immature specimens of the lower Oligocene species (for instance, pl. 29, figs. 6, 8) it is quite obvious that they are derived from the "*G.*" *trituberculata* stock. The Oligocene species become larger and the spiral ribbing becomes coarser by the obsolescence of inter-ribs.

Species referrable to *Echinophoria* are:

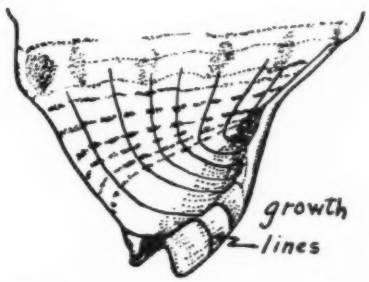


FIG. 2—*Echinophoria trituberculata* (Weaver). Sketch of anterior canal, lateral view, tip broken. Note notch in growth line.

1. *Echinophoria trituberculata* (Weaver) Pl. 29, fig. 10.
   Morio tuberculata Gabb, var. *trituberculata* Weaver, *1912*, Wash. Geol. Surv. Bull. 15, pp. 39–40, pl. 3, fig. 35.
   Galeodea trituberculata (Weaver), Tegland (*partim*) *1931*, California Univ. Geol. Sci. Bull., vol. 19, p. 408, pl. 59, fig. 1, pl. 60, figs. 1–4.
   Horizon: Eocene, Cowlitz (Washington).

As before noted [under *Galeodea* (*Gomphopages*) n. sp.] two species have been confused under this name. It is only Weaver's original species that may be referred to *Echinophoria* Sacco.

2. *Echinophoria dalli* (Dickerson) ?, variety Pl. 29, figs. 6, 7, 8, 11.
   Horizon: Oligocene, Keasey (Oregon).
3. *Echinophoria dalli* (Dickerson) Pl. 29, fig. 4; pl. 30, fig. 5.
   Galeodea dalli Dickerson, *1917*, California Acad. Sci. Proc. ser. 4, vol. 7, p. 176, pl. 30, fig. 8a (not 8b).
   Horizon: Oligocene, Gries Ranch (Washington).
4. *Echinophoria fax* (Tegland) Pl. 30, fig. 4.
   Galeodea fax Tegland, *1931*, California Univ. Geol. Sci. Bull., vol. 19, pp. 410–412, pl. 60, figs. 5–11.
   Horizon: Oligocene, Lincoln (Washington).
5. *Echinophoria rex* (Tegland) Pl. 30, figs. 1, 2, 3.
   Galeodea rex Tegland, *1931*, California Univ. Geol. Sci. Bull., vol. 19, pp. 413–415, pl. 60, fig. 12, pl. 61, figs. 1–4, pl. 62, figs. 1–6.

Horizon: Oligocene, Blakeley (Washington).

6. *Echinophoria apta* (Tegland) Pl. 30, figs. 6, 7, 8.
Galeodea apta Tegland, *1931*, Univ. Calif. Publ. Geol. Sci., vol. 19, pp. 415–417, pl. 63, figs. 1–10, pl. 64, figs. 1–2.
Horizon: Oligocene, Upper Twin Rivers (Washington).

Galeodea petrosa (Conrad) (1849) has several characters which seem to indicate a lineage different from the Oligocene "Galeodeas," e.g., the denticulate outer lip and the different plan of spiral ribbing. Unfortunately no material is available showing a complete anterior canal.

At first sight *Galeodea tuberculiformis* Hanna appears to be similar to "*Galeodea*" *trituberculata* (Weaver), but closer examination shows that it lacks the ridge anterior to the columellar fasciole and the notched anterior canal found in *Echinophoria*. The former species has a low naticoid protoconch like *Galeodea* and a somewhat similar anterior canal, otherwise it appears to differ from *Galeodea*. It has the following characters not found in true members of that genus: a slightly corded sutural collar, several spire varices always present, fine beaded spiral sculpture (formed by intersection of growth lines with spiral ribs in a manner somewhat like the "honeycombs" on *Cassis cornuta* (Linné)), the immediate post-nuclear whorls have radial ribs as strong as or stronger than the spirals, on successive whorls these radials become progressively obsolete except at their intersection with the three major spirals, these intersections become the nodes found in the adult shell. Thus these nodes are of different origin than in *Galeodea* where the immediate post-nuclear whorl does not have radial sculpture, only spiral, and the nodes appear later in the ontogeny. The species has some characters which seem to relate it to *Cassis*, namely, the beaded sculpture having a similar origin to the "honeycomb" on *Cassis cornuta* (the genotype), and the corded suture also being found in the immature stages of that species. However, the protoconch of the genotype of *Cassis* is high and not naticoid, with no sharp demarcation on available specimens, whereas it is sharply set off on "*G.*" *tuberculiformis*, and the immediate post-nuclear sculpture seems to be spiral instead of both spiral and radial.

No genus has been found into which Hanna's species will fit so the new genus *Coalingodea* is herewith proposed, with *Galeodea tuberculiformis* Hanna (pl. 29, figs. 5, 9) = *Morio Sconsia*) *tuberculatus* Gabb, 1864 as genotype. *Coalingodea* will include those "Galeodean" species with a naticoid protoconch, immediate post-nuclear ornamentation both radial and spiral, the nodes of the adult derived from the intersection of the major nuclear spirals and radials, a "corded" suture, several spire varices, inner and outer lips always dentate, and with finely beaded spirals, the beading due to intersection with the growth lines. At present only the one species is known. This species, "*Galeodea*" *tuberculiformis* Hanna, has been well figured and described by Schenck (1926, p. 83, pl. 14, figs. 12, 13, 16, *not* 14, 15, which are near to *G. meganosenis* Vokes) and by Vokes (1939, N. Y. Acad. Sci. Ann., vol. 38, pp. 149–150, pl. 19, figs. 19, 21, 23–27). It is known from the Domengine, (middle) Eocene, in California.

Galeodea crescentensis Weaver and Palmer (1922) is an anomalous species. Unfortunately but little material is available for examination, one immature and one partially crushed adult topotype (Univ. California Mus. Pal. hypotypes nos. 12593 and 31310) are at hand. There is a well marked "corded" sutural collar, the anterior canal is quite short and almost closed in front. The outer lip is dentate and has a heavy varix. Denticulations are also present on the inner lip and columella, resembling those of *Coalingodea tuberculiformis* (Hanna). The spiral sculpture is nearly similar to *Echinophoria trituberculata* (Weaver) but the prominent spirals are much fewer in number with extremely fine spirals intercalated. On the shoulder above the first row of prominent nodes a single centrally located prominent spiral bears incipient nodes in the last half volution. The type of ornamentation does not resemble that of any other *Galeodea* known to the author; however, lack of adequate material prevents its accurate allocation at this time.

STRATIGRAPHY

During a recent examination of the type section of the Twin Rivers formation (Weaver, 1937, p. 117, and Tegland, 1933,

p. 90), upper Oligocene of Washington, a considerable number of "Galeodeas" were collected by the writer. The Twin Rivers is generally correlated with the type Blakeley, upper Oligocene. Examination reveals that both "*Galeodea*" *rex* Tegland and "*G.*" *apta* Tegland (1931, pp. 413–417, pls. 61–64) are represented in the material. As noted previously the Oligocene species are to be referred to *Echinophoria* Sacco.

As may be seen in Tegland's later work (1933, p. 90), she considered the Twin Rivers formation to extend for a distance of about 3 miles in either direction, east and west from the Twin Rivers valley on the Washington shore of the Strait of Juan de Fuca. The new *Echinophoria* material collected by the author all comes from within the limits of the formation as defined above. Only *E. rex* was found at points between one and one-half and two and one-half miles east of East Twin River, and only *E. apta* was found at positions higher in the section, to the west of the area one and one-half miles east of East Twin River.

The appearance of these two species in the same section is contrary to the belief of Tegland (1931, p. 401), who states that *E. rex* developed in the type Blakeley area simultaneously with *E. apta* in the Twin River area, that both had a common ancestor. Tegland believes that the line of *E. rex* apparently came to an end with the close of Blakeley time, while the line of *E. apta* continued on into the Miocene species "*Galeodea*" *petrosa* (Conrad).

In discussing *E. apta*, Tegland (1931, p. 402, footnote 8) considered that the immature shells were similar to, but not identical with *E. rex*. Yet an immature paratype of *E. apta* (pl. 30, fig. 6; compare with fig. 2) shows all the essential characters of *E. rex* cited by Tegland. The former exhibits a concave tabulate shoulder, a crenulate suture, heavy nodes on the shoulder, two well defined rows of nodes and a faintly developed third row. The only differences from *E. rex* are slight generalizations of sculpture such as are to be expected in recapitulation of the phylogeny. Unfortunately all individuals found near the transition point between *E. rex* and *E. apta* in the Twin Rivers sequence were either very fragmentary or immature so that there is no definite proof of the evolution from one species to the other. Nevertheless, it seems to the author that stratigraphic superposition plus the recapitulation of older characters in juvenile stages is indicative of the descent of *E. apta* from *E. rex*.

Later Tegland states (1931, p. 402), "The diversity of form in the Twin Rivers *Galeodea* is characteristic of that species alone in the series under discussion. The state of flux exhibited might be expected toward the close of an epoch when active diastrophism causing rapid change in environment results in accelerated evolution with adaptation to new conditions." Yet the Twin Rivers shale is rather uniform in character, consisting largely of clayey and silty shale with some sandy shales and a few minor sandstone beds, indicating but little change in the conditions prevailing in the land areas supplying the sediments, whereas in the type Blakeley area some 75 miles to the southeast, *E. rex* is found in a thick shale sequence which includes important amounts of sandstone and coarse conglomerate, indicating rapidly changing environments at the source of the sediments. Nevertheless *E. rex* apparently continues unchanged through most of the 9,000 feet of varying Blakeley sediments; whereas during the same time interval, *E. apta* is supposed to have varied specifically in the comparatively uniform Twin Rivers sequence with no known geological barrier to separate the two areas. Yet on the assumption of accelerated evolution due to changing environments, *E. rex* should have changed more than *E. apta*.

All specimens of *E. rex* found were more or less crushed. However, the individual figured on Plate 30, figures 1 and 3, shows all the distinguishing characters of the species, i.e., a heavily noded, tabulate shoulder, three rows of nodes, crenulate suture and heavy spiral ribs. Figure 2 is the holotype, illustrated for comparison. Material referable to this species was found at several points along the sea cliff between one and one-half and two and one-half miles east of the mouth of East Twin River. As before noted, all material west of this point appears to belong to *E. apta*. No evidence of an unconformity was noted here but as the exposures are not continuous, its absence cannot positively be ascertained. All the *E.*

apta material figured by Tegland is described as coming from localities west of this point.

Despite Tegland's statement to the contrary (1931, p. 401), it appears that *E. apta* is more closely related to *E. rex* than it is to "*Galeodea*" *petrosa* (Conrad)[1] of the Miocene. The fewer spiral ribs below the shoulder on "*G.*" *petrosa*, 10, as compared to the usual 15 on *E. apta* and *E. rex* indicates the close relationship of the latter two species.

Only *E. rex* has been found so far within the type Blakeley sequence, and it occurs from the base to the top of the fossiliferous part of the formation; that is, the part which bears the well known type Blakeley, upper Oligocene fauna. In the Twin Rivers area, only the lowermost part of the Twin Rivers shale bears *E. rex*, the upper part being characterized by *E. apta*. Therefore, it may be assumed that only the lower part is equivalent to that part of the type Blakeley bearing the characteristic fauna, and that the upper Twin Rivers shales are younger in age. However, it is possible that the upper 1300 feet of Blakeley conglomerate [belt A of Weaver (1916, p. 48)], which as yet has yielded no marine fauna, may be equivalent in whole or in part of the upper Twin River shales. This younger age for the major part of the Twin Rivers shale also explains the common resemblance of immature shells from there with the adult Blakeley shells, and the specific differences in the same genera that Tegland has noted previously (1933, p. 91).

The implications of the indicated younger age for the upper Twin Rivers shale on the Blakeley-Vaqueros correlation of Kleinpell (1938, fig. 14) is yet to be evaluated. It should be noted that according to Weaver (1937, p. 131) the Twin Rivers shale is unconformably overlain by the Clallam formation which is, in turn, correlated with the Astoria formation (Weaver, 1937, p. 175) of southwestern Washington and Oregon.

No new data regarding *E. fax* (Tegland) (1931, pp. 410–412, pl. 60, figs. 5–11) has been gathered. Apparently the usual facies of the middle Oligocene in Washington was not favorable to its development. Nevertheless it should be noted that the paratype

[1] Upon examination of the original of figures 6 and 7 of Plate 65 of the 1931 work which is labeled *G. petrosa* (Conrad), it is readily apparent that this is a misidentification and that the specimen is actually an immature individual of *E. apta*. One otherwise typical, mature specimen of *E. apta* now at hand shows a few similar, fine tertiary spirals on the body whorl.

Explanation of Plate 29

All type and locality numbers refer to the University of California Museum of Paleontology collections unless otherwise noted. Fig. 9 after Vokes (1939), fig. 10 after Tegland (1931).

Figs. *1*—*Buccinum echinophorum* Linne, ×1+, hypotype no. 12594, Recent, Mediterranean Sea. A variant with dentate lip and heavy varix. (p. 183)

2—*Galeodea* (*Gomphopages*) *sutterensis* (Dickerson), ×1+, Holotype no. 11782, loc. 1853, Marysville Buttes. Canal outline restored after growth lines. (p. 184)

3—*Buccinum echinophorum* Linne, ×1+, hypotype no. 12595, Recent, Mediterranean Sea. A variant with light varix and no denticles. (p. 183)

4—*Echinophoria dalli* (Dickerson), ×1+, hypotype no. 33590, loc. 3607, type Gries Ranch. Note heavy midspiral on shoulder. (p. 185)

5—*Coalingodea tuberculiformis* (Hanna), ×1+, hypotype no. 15807, loc. 672, Domengine Eocene, north of Coalinga. Note denticles on inner and outer lip. (p. 186)

6—*Echinophoria dalli* (Dickerson)?, variety ×1¾+, hypotype no. 392, Schenck Coll., Stanford Univ., loc. H. 63, Keasey formation (Oregon). Note heavy midspiral on shoulder. An immature individual. (p. 190)

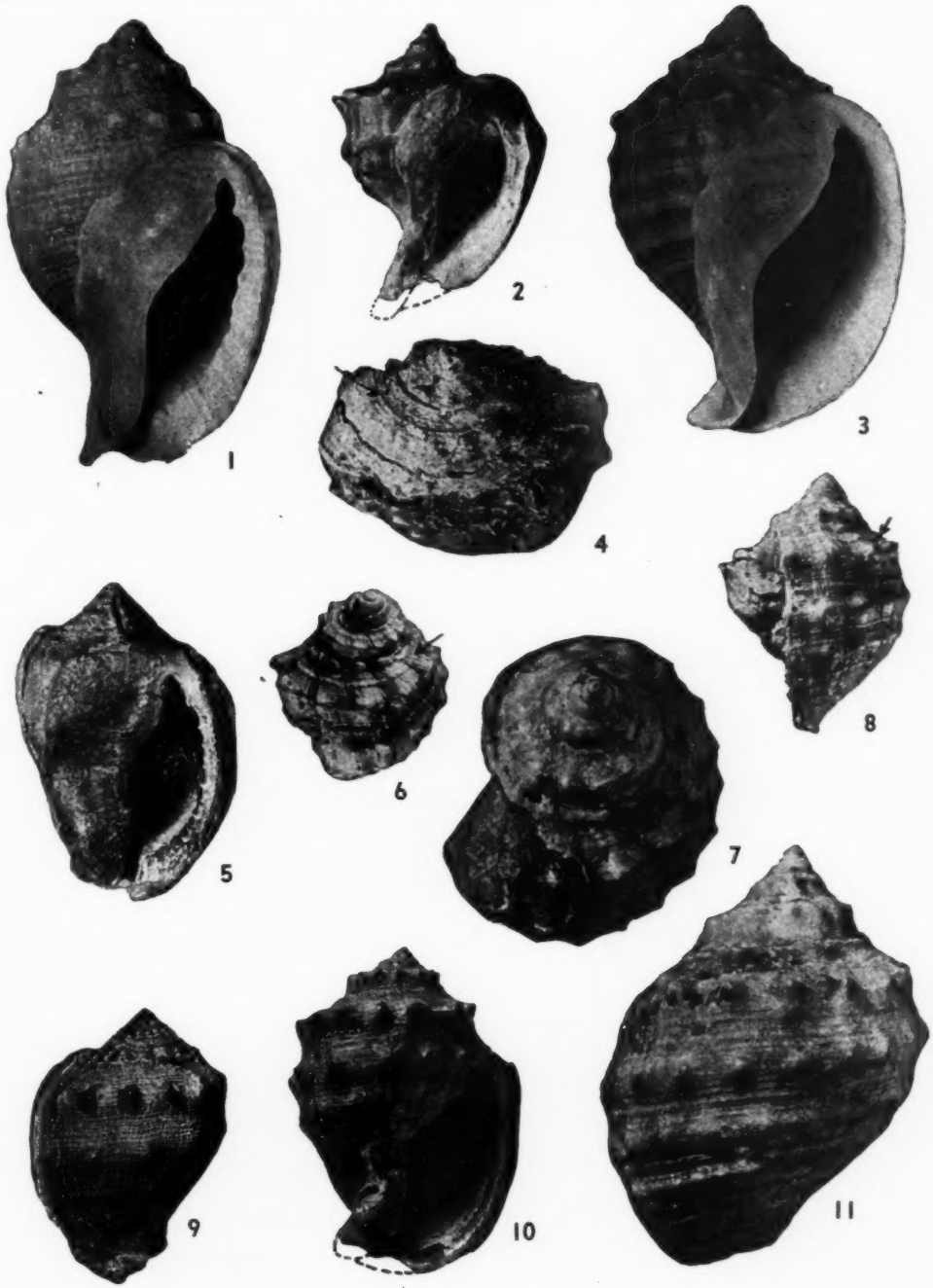
7—*Echinophoria dalli* (Dickerson)?, variety ×1½+ (same specimen as fig. 11), Hypotype no. 365, Schenck Coll., Stanford Univ., loc. H. 38, Keasey formation (Oregon). Note heavy midspiral on shoulder. Specimen somewhat worn. (p. 190)

8—*Echinophoria dalli* (Dickerson)?, variety ×2.0, (same individual as fig. 6). Note heavy midspiral on shoulder. (p. 190)

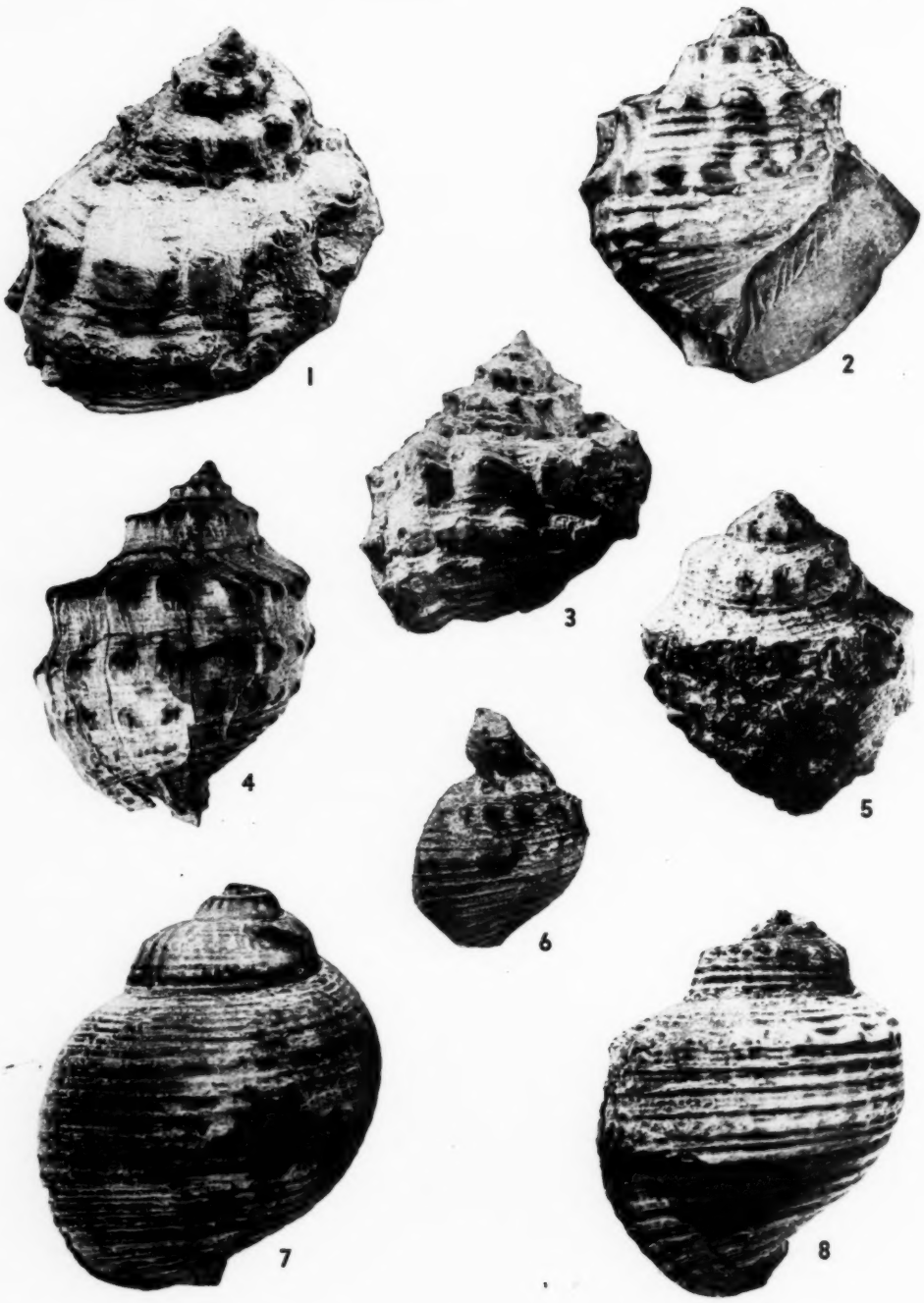
9—*Coalingodea tuberculiformis* (Hanna) ×1.8, hypotype no. 11783, loc. 672, Domengine Eocene north of Coalinga. Note beaded spiral sculpture and short canal. (p. 186)

10—*Echinophoria trituberculata* (Weaver) ×0.97, hypotype no. 31311, loc. 7162, Cowlitz Eocene (Washington). Note short canal and corded sutural collar. Canal restored. (p. 185)

11—*Echinophoria dalli* (Dickerson)?, variety ×1.70, (same individual as fig. 7). Note low shoulder. (p. 190)



Durham, Tertiary Galeodeas



Durham, Tertiary Galeodeas

from the type Lincoln (Univ. California Mus. Pal. no. 32066, Tegland 1931, pl. 60, figs. 9, 10) is not typical of the species. The individual is somewhat worn and has been encrusted with barnacles. It presents a number of features that may be gerontic or it might represent a new species. Lacking other material from the same locality nothing has been done with it. Further the California Academy of Science paratype, no. 5334 (Tegland, 1931, pl. 60, fig. 11) is not typical of *E. fax*, it appears to belong to the *E. dalli* group and is probably the same as the variety of *E. dalli* figured here (pl. 29, figs. 6, 7, 8, 11) from the Keasey formation of Oregon. The spire is higher and the shoulder nodes are less prominent. Although it is somewhat worn it shows evidence of the prominent midspiral present on typical *E. dalli*.

The lower Oligocene species *E. dalli* (Dickerson) [1917, p. 176, pl. 30, fig. 8a (not 8b)] was originally described from an immature individual. Since then considerable doubt has been cast upon the validity of the species (Tegland, 1931, p. 410, and Effinger, 1938, p. 382). The only mature "*Galeodea*" yet found at the type locality is quite incomplete and was referred by Effinger (*loc. cit.*) to *G.* cf. *fax* Tegland and as "indistinguishable from *G. fax* Tegland."

This specimen, University California Mus. Pal. Hypotype no. 33590 (pl. 29, fig. 4 and pl. 30, fig. 5), has been re-examined and the following differences from *E. fax* noted. First, the spiral ribs between the first and second rows of nodes on the body whorl are apparently all of the same size; whereas on *E. fax*, the spiral just below the center is much more prominent than the others; second, on the shoulder above the first row of nodes, there are but four or five subequal spirals not as wide as their interspaces, while on *E. fax*, there are about seven subequal spirals as wide as their interspaces; third, the central spiral on the shoulder is much more prominent than the rest (the immature type specimen shows this same prominent spiral also), this character is not found on *E. fax*, but is found on the ancestral *E. trituberculata* (Weaver) of the Eocene; finally, the nodes are not nearly as prominent as on *E. fax*. Because this is topotype of *E. dalli* with the same type of spiral ribbing, and in view of the above noted differences from *E. fax*, it appears that these characters should be considered as representing those of the mature *E. dalli*. *E. dalli* should be ranked as a distinct species. This is in contrast to the view of Effinger (*loc. cit.*) who, by inference, would consider *E. fax* a synonym of *E. dalli*, with *E. dalli* representing an immature stage of *E. fax*. The third row of nodes is definitely represented on this individual, but the number of rows of nodes present on the Oligocene species appears to depend on the size and age of the individual. A mature paratype of *E. apta* (University California Mus. Pal. no. 32078 (shows slight traces of the third row of nodes, while on other individuals only faint evidence of the first row of nodes is to be seen.

Recently Schenck (1936, pp. 44, 62, 63)

EXPLANATION OF PLATE 30

Figs. 4, 6, 7, 8 after Tegland (1931)

FIGS. *1*—*Echinophoria rex* (Tegland) ×1+, hypotype no. 12211, loc. A 3440, lower Twin Rivers shale. Oblique view of spire. Specimen somewhat crushed. (p. 185)

2—*Echinophoria rex* (Tegland) ×¾−, holotype no. 32067, loc. 681, Blakeley formation. (p. 185)

3—*Echinophoria rex* (Tegland) ×¾+. Same specimen as fig. 1. Lateral view. (p. 185)

4—*Echinophoria fax* (Tegland) ×1−, holotype no. 32064, loc. A 730, Porter shales. (p. 185)

5—*Echinophoria dalli* (Dickerson) ×1+, hypotype no. 33590, loc. 3607, Gries Ranch beds. (p. 185)

6—*Echinophoria apta* (Tegland) ×1. Paratype no. 32077, loc. A 6, lower Upper Twin Rivers shales. A young individual with nodes and general ornamentation of *E. rex* Tegland (p. 186)

7—*Echinophoria apta* (Tegland) ×1−. Paratype no. 32075, loc. A 6, lower Upper Twin Rivers shale. A typical, mature individual of the type usually found in the Upper Twin Rivers shale. (p. 186)

8—*Echinophoria apta* (Tegland) ×1−, holotype no. 32071, loc. A 6, lower Upper Twin River shale. A nearly mature individual with slightly developed nodes. (p. 186)

listed "*Galeodea*" *fax* Tegland from the Keasey formation of Oregon. Upon examination, all of the determinable specimens, except one, appear to represent a variety of *E. dalli*. The exception is an undescribed species of *Olequahia* Stewart. The description of the variety is as follows:

Echinophoria dalli (Dickerson)?, variety
Plate 29, figures 6–8, 11

Galeodea fax Tegland, Schenck, *1936*, Geol. Soc. Am. Spec. Pap. no. 4, pp. 44, 62 (partim), 63.
Galeodea fax Tegland, *1931*, Univ. California Geol. Sci. Bull., vol. 19, pl. 60, fig. 11.
non Galeodea fax Tegland, *1931*, Univ. California Geol. Sci. Bull., vol. 19, pp. 410–412, pl. 60, fig. 5–10.
non Galeodea fax Tegland, Schenck, *1936*, Geol. Soc. Am. Spec. Pap. no. 4, p. 62, loc. H. 36 (=*Olequahia* n. sp.).

Adult similar to that of typical *E. dalli*, but with a higher spire and a more prominent sutural collar. Immature individuals (pl. 29, figs. 26, 8) are superficially quite similar to young *G. trituberculata* Weaver, but close inspection shows that the sutural collar is heavier, the midspiral on the shoulder is very prominent and there is a heavy midspiral between the first and second rows of nodes, while anteriorly the spirals at the base of the whorl are quite heavy, foreshadowing the heavy spirals of the later Oligocene species.

Dimensions:

	height	*maximum diameter*
Hypotype 365 (incomplete	35.2 mm.	27.0 mm.
Hypotype 392 (incomplete)	18.0 mm.	13.5 mm.

Hypotype no. 365 Schenck Collection, Stanford University, Holman loc. 38.

Hypotype no. 392 Schenck Collection, Stanford University, Holman loc. 63.

Occurrence.—Keasey formation of Oregon, Holman localities H. 25, H. 38, H. 40, H. 63, H. 68, N. P. 308.

With *E. rex* shown to be older than *E. apta*, all of the known Oligocene *Echinophoria* species become good index fossils. The succession from youngest to oldest is: *E. apta* (Tegland), *E. rex* (Tegland), *E. fax* (Tegland), *E. dalli* (Dickerson). The zonation of the Washington Oligocene will be taken up in a later paper, based upon more lines of evidence.

Peculiar characteristics of the various Oligocene species are as follows:

E. apta (Tegland)—spiral ribs cordlike, heavy, nodes usually obsolete, body whorl profile rounded, suture abutting.

E. rex (Tegland)—spiral ribs as in *E. apta*, body whorl heavily carinated by three to four rows of nodes, shoulder above first row of nodes, but slightly concave, suture appressed.

E. fax (Tegland)—spiral ribs not cordlike except anteriorly on body whorl, body whorl strongly carinated by three rows of nodes, shoulder above first row of nodes strongly concave, suture appressed, spirals above shoulder of even size, 7 to 8 in number.

E. dalli (Dickerson)—spiral ribs as in *E. fax*, body whorl less strongly carinated than in *E. fax*, a slight sutural collar present, spirals above shoulder 4 or 5 with a medial spiral much more prominent than rest.

E. dalli (Dickerson)? variety—similar to typical *E. dalli* but with a well marked sutural collar and slightly higher spire. Immature specimens resemble *E. trituberculata* (Weaver) of the Eocene.

LOCALITY DESCRIPTIONS

672. Eocene, Domengine, north of Coalinga, California. SE ¼ of N. W. ¼ of Sec. 24, T. 18 S., R. 14 E., Mount Diablo base and meridian. 0–10 feet below white shale. Parsons Peak.
681. Upper Oligocene, type Blakeley formation. At Restoration Point, Bainbridge Island, Kitsap County, across Puget Sound from Seattle, Washington.
1853. Eocene, Capay, Marysville Buttes. "2 miles 80° west of south Butte, second small gully north of low divide, "Fig. Tree Gulch," 100–400 feet below the basal zone in Eocene. Marysville Quadrangle."
3607. Lower Oligocene, type Gries Ranch beds. Southeast bank of Cowlitz River, Lewis County, Washington, Sec. 25, T. 11 N., R. 2 W., Willamette base and meridian.
7162. Upper Eocene, Cowlitz formation. West bank of Cowlitz River at bend in SE ¼ Sec. 27, T. 11 N., R. 2 W.
A 6. Upper Oligocene, upper type Twin Rivers shale, Clallam County, Washington. In shale cliffs on beach about one-half mile southeast of mouth of east Twin River.
A 730. Middle Oligocene, Porter shales. "A few hundred paces west of the type Porter locality," between the towns of Porter and Malone, Chehalis County, Washington.
A 3440. Upper Oligocene, lower type Twin Rivers shale. Clallam County, Washington. One and one-eighth miles east along beach from the 123°55′ line on Lake Crescent Quadrangle. In grey-

black shales above a marked thrust fault plane.

H. 25. Lower Oligocene, Keasey formation, Washington County, Oregon. Near center of Sec. 27, T. 1 N., R. 4 W. Gales Creek Road, 3 miles northwest of Forest Grove.

H. 38. Lower Oligocene, Keasey formation, Washington County, Oregon. Center of north line of NW ¼ of sec. 8, T. 3 N., R. 4 W. Cut in bank along United Railroad.

H. 40. Lower Oligocene, Keasey formation, Columbia County, Oregon. Near center of NE ¼, Sec. 8, T. 4 N., R. 4 W., one mile south of Vernonia on road to Timber.

H. 63. Lower Oligocene, Keasey formation, Columbia County, Oregon. Near center of SW ¼ Sec. 30, T. 5 N., R. 4 W. Prominent exposure in road cut along Rock Creek: road to Keasey. Also in railroad cut just below.

H. 68. Lower Oligocene, Keasey formation, Columbia County, Oregon. SE corner Sec. 27, T. 5 N., R. 5 W. In prominent cut in west bank of Rock Creek at west end of United R. R. trestle, 350 feet south of Rock River road.

N. P. 308. Lower Oligocene, Keasey formation. Washington-Columbia County line, Oregon. Sec. 31, T. 3 N., R. 5 W., Road cut 6 miles north of Timber.

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PALEONTOLOGY OF THE EAGLE FORD GROUP OF NORTH AND CENTRAL TEXAS

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ABSTRACT—The Eagle Ford strata contain numerous genera and species of ammonites which are usually well preserved and locally abundant. Fifteen new species are herein named and described. Pelecypods, particularly Inocerami, are abundant but only a few species of Inocerami have been identified. Many species of Eagle Ford ammonites and most of the Inocerami have a limited vertical range and are confined to definite zones which have a wide geographic distribution. The Tarrant, Britton, and Arcadia Park formations, which comprise the Eagle Ford group, are correlated with rocks of similar age in other areas. Fossil lists are included for each formation.

INTRODUCTION

THIS paper is part of a general study of the Eagle Ford group of north and central Texas which was presented as a dissertation in partial fulfillment of the requirement for the degree of Doctor of Philosophy in the department of geology at the University of Kansas.

The Eagle Ford was named by R. T. Hill from a village situated on the Texas and Pacific railroad six miles west of Dallas, Texas. His investigations of the Cretaceous rocks of Texas covered particularly the Black and Grand prairies, and in his last report (Hill, 1901) on this area, he describes fully the formations of the Comanche and Gulf series. The Gulf series includes, from the base upwards, the Woodbine, Eagle Ford, Austin, Taylor, and Navarro groups.

W. S. Adkins (1932) considered the Eagle Ford as a group for the first time and summarized all the knowledge concerning the group to that date.

The writer (1932) described three divisions for the Eagle Ford group, which are, from the base upward, Tarrant formation, Britton formation, and Arcadia Park formation. The accompanying correlation chart (fig. 1) is an attempt to show the character of the Eagle Ford group in north and central Texas.

During the course of this research, the writer has received assistance of various sorts from other geologists familiar with the subject. This paper was written under the supervision of Dr. R. C. Moore, University of Kansas, Lawrence, Kansas. Professor W. M. Winton and Dr. Gayle Scott of Texas Christian University, Fort Worth, Texas, accompanied the writer on many field trips and offered helpful suggestions. Dr. E. H. Sellards, Director of the Bureau of Economic Geology, Austin, Texas, has shown a great interest in this work and has aided in various ways. Dr. John B. Reeside, Jr., U. S. Geological Survey, Washington, D. C., has examined part of the material herein described and has offered much helpful advice. The writer is especially indebted to W. S. Adkins, Shell Petroleum Company, Houston, Texas, for access to his collection of Eagle Ford fossils, and for his many helpful suggestions. Others who have contributed in various ways are, N. L. Thomas, Pure Oil Company, Fort Worth, Texas; C. I. Alexander, Magnolia Petroleum Company, Tyler, Texas; F. B. Plummer and Helen Jeanne Plummer, Bureau of Economic Geology, Austin, Texas.

PALEONTOLOGY

Since the Eagle Ford has been designated as a group and divided into three formations, there has arisen a need for a finer definition of the fossils in that group to determine the species that occur in each formation, and to establish their limits. Ammonites and certain pelecypods, particularly Inocerami, lend themselves very readily to stratigraphic work and have proven very valuable in the Eagle Ford group, because they have a limited vertical range and a wide geographic distribution. It has seemed advisable, therefore, to work out the species of ammonites and Inocerami of the Eagle Ford group in as much detail as possible and simply to list the other fossil species which have been identified from this group.

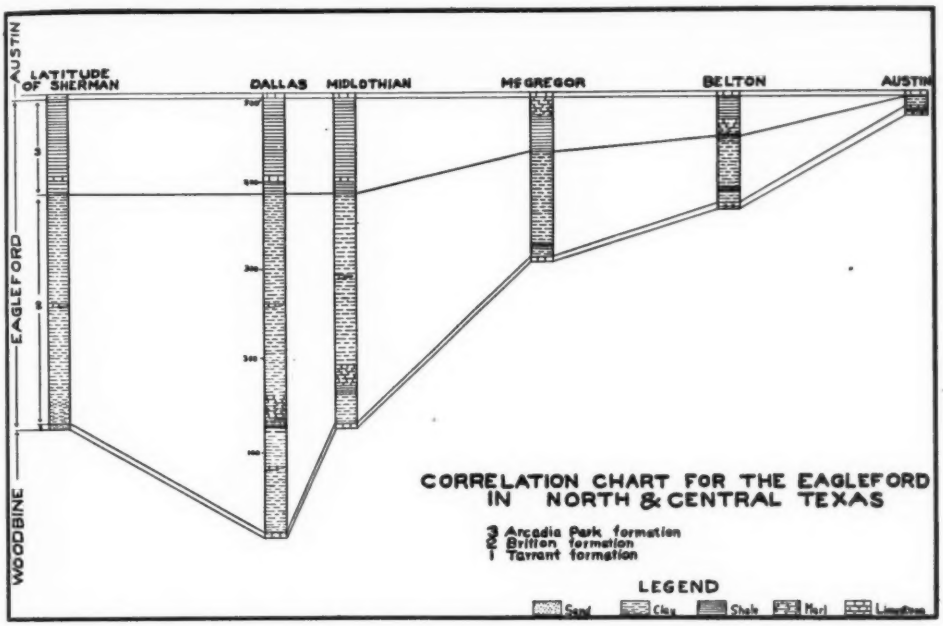


FIG. 1—Columnar sections of the Eagle Ford group in Texas.

Zones of the Eagle Ford.—The first study with regard to the vertical range of the Eagle Ford fossils was made by Scott (1926, p. 190). He recognized three zones which are as follows:

Zone of *Metoicoreras whitei*
Placenticeras placenta
Heliococeras pariense
Prionotropis woolgari
Zone of *Inoceramus labiatus*
Zone of *Acanthoceras rotomagense*

In a later paper Scott (1926, p. 632) considered *Prionotropis* aff. *woolgari* Mantell as representing a distinct zone just above *Metoicoceras whitei* Hyatt.

Nine zones were proposed by the writer (1927, pp. 89–101) for the Eagle Ford, which for convenience are here listed.

Zone of Eagle Ford-Austin chalk transgression
Zone of *Prionotropis woolgari*
Zone of *Gauthiericeras* aff. *bravaisi*
Zone of *Metoicoceras gibbosum*
Zone of *Helicoceras pariense*
Zone of *Metoicoceras swallovi*
Zone of *Metoicoceras whitei*
Zone of *Metoicoceras irwini*
Zone of *Acanthoceras* aff. *rotomagenes*

Further collecting and study of the species has revealed that the specimen referred to *Acanthoceras* aff. *rotomagense* is *Acanthoceras inaequiplicatum;* that *Metoicoceras gibbosum* Hyatt, *Heliococeras* (now referred to *Allocrioceras*) *pariense* White, and *Metoicoceras whitei* are associated together; that the specimen identified as *Metoicoceras swallovi* has only a superficial resemblance to this species and is here being given a new name; that the specimen referred to as *Gauthiericeras* aff. *bravaisi* Sharpe was misidentified and is synonymous with *Prionotropis* aff. *woolgari.*

Adkins (1932, p. 432) divides the Eagle Ford tentatively into the following paleontological zones:

8. *Alectryonia lugubris* zone
7. *Prionocyclus-Prionotropis* zone
6. *Coilopoceras* zone
5. *Romaniceras-Metoicoceras whitei* zone
4. *Neocardioceras* zone (*Pseudaspidoceras*)
3. *Eucalycoceras bentonianum* zone
2. *Acanthoceras wintoni* zone
1. *Acanthoceras tarrantense* zone

Adkins also in the same paper lists local

zones for the Eagle Ford throughout the state compiled from the literature and his own research. In the above list, *Romaniceras* is placed with *Metoicoceras whitei*, but it occurs more typically at a higher level.

There are only five zones which can be recognized over a wide area; one in the Tarrant formation, two in the Britton formation, and two in the Arcadia Park formation. The zones and subzones of the Eagle Ford group in north and central Texas are as follows:

Arcadia Park Formation

Zones—Subzones
Alectryonia lugubris
Prionotropis aff. *woolgari*
Prionocyclus meekianus
Coilipoceras eaglefordensis
Romaniceras sp.
Prionotropis hyatti
Prionotropis graysonensis

Britton Formation

Metoicoceras whitei
Barroisiceras trinodosum
Worthoceras vermiculum
Allocrioceras pariense
Metoicoceras irwini
Neocardioceras septemseriatum
Eucalycoceras bentonianum
Epengonoceras acutum
Tragodesmoceras scotti

Tarrant Formation

Acanthoceras inaequiplicatus
Metoicoceras swallovi
Acanthoceras alvaradoense
Acanthoceras sherborni
Acanthoceras wintoni
Mantelliceras sellardsi

The Inocerami are rather abundant in the Eagle Ford group and can be roughly placed into the following zones:

Arcadia Park formation

Inoceramus dimidius

Britton formation

Inoceramus fragilis
Inoceramus capulus
Inoceramus labiatus

Tarrant formation

Inoceramus sp.

Acanthoceras inaequiplicatum occurs in abundance in northeastern Tarrant County, 2.25 miles east of Tarrant, Texas; and several specimens have been found in Bell County between Temple and Belton, Texas. The holotype came from Garret's Bluff on Red River in Fannin County.

Metoicoceras irwini Moreman was first described from an exposure in Dallas County, six miles northwest of Irving, Texas, and has also been collected in Ellis County. As yet this species has not been recorded north of Dallas County nor in central Texas.

Metoicoceras whitei is one of the most abundant and characteristic ammonites of the Britton formation; *Prionotropis* aff. *woolgari* is very abundant in the lower and middle part of the Arcadia Park formation and the pelecypod, *Alectryonia lugubris* (Conrad), occurs abundantly in the upper part of the Arcadia Park formation at numerous exposures in north and central Texas.

Correlation.—The Eagle Ford group is approximately equivalent to the upper Cenomanian and Turonian of the European sections. The Tarrant formation contains an Acanthocerata fauna very similar to that of the upper Cenomanian. In fact, a number of specimens have been referred to European species such as *Acanthoceras* aff. *sherborni* Spath, *Acanthoceras* aff. *cunningtoni* (Sharpe), *Acanthoceras* aff. *cunningtoni* var. *cornutum* Kossmat, *Acanthoceras* aff. *rotomagense* (de France), and *Acanthoceras* aff. *hunteri* Kossmat. Two other typical Cenomanian ammonoids found in the Tarrant formation are: *Turrilites* aff. *costatus* Lamarck, and *Turrilites* aff. *desnoyersi* d'Orbigny.

The fauna of the Britton formation corresponds very closely to that of the lower Turonian or "Salmurian" of Europe. *Metoicoceras irwini*, which occurs in the lower part of the Britton formation, is closely related to *Metoicoceras pontieri* Leriche in the base of the Salmurian. Such genera as *Neocardioceras*, *Eucalycoceras*, *Scaphites*, *Baculites*, *Proplacenticeras*, and *Allocrioceras* are characteristic of both the lower Turonian and the Britton formation. Another characteristic form found at about this same stratigraphic level in both Europe and America is *Inoceramus labiatus*.

The Arcadia Park formation contains numerous species of *Prionotropis*, *Prionocyclus*, *Romaniceras* and *Coilopoceras* which are closely related to species of the same genera in the upper Turonian or "Angoumanian" of Europe. Young individuals of *Prionotropis* aff. *woolgari* (a common European species) are especially abundant in the lower part of the Arcadia Park formation.

The Eagle Ford group corresponds very closely to the Benton group of the western interior. In the Great Plains region the Benton group is divided into three formations, which are named from the base upward: Graneros shale, Greenhorn limestone, and Carlile shale. The lower part of the Graneros contains species of *Acanthoceras* closely related to *Acanthoceras* aff. *sherborni* of the Tarrant formation. The Greenhorn limestone contains among others, *Inoceramus labiatus*, *Metoicoceras whitei*, *Neocardioceras septem-seriatum* and *Allocrioceras pariense*, species which are characteristic of the Britton formation. The upper part of the Graneros probably corresponds to the lower part of the Britton formation. The Carlile shale contains species of *Prionocyclus*, *Prionotropis woolgari*, and *Scaphites* very similar to species of the same genera in the Arcadia Park formation. *Prionotropis* aff. *woolgari* is common at approximately the same stratigraphic level throughout Texas and the western interior.

A sandstone in western Colorado, forming the uppermost part of the unit generally called Dakota(?) sandstone, and the lowermost Mancos shale of Colorado contains *Acanthoceras* aff. *rotomagense* (Reeside, 1927, pp. 453–454). This species is common in the upper Cenomanian and likewise found in the Tarrant formation. Many genera and some species which occur in the Turonian part of the Eagle Ford group (Arcadia Park and Britton formations) are common in the Mowry shale of eastern Wyoming, the Aspen shale of southwestern Wyoming, and the lower Mancos shale of western Colorado and New Mexico.

The ammonite zones of the upper Turonian represented by species of *Romaniceras*, *Coilopoceras*, *Pseudojacobites*, and others are rare in the Arcadia Park formation of north Texas. *Coilopoceras* aff. *eaglefordense* Adkins has been reported from the base of this formation in western Dallas County. *Coilopoceras* and *Romaniceras* are present at the top of the Eagle Ford at Austin and in southwest Texas and Mexico, where the Turonian fauna is well developed.

FOSSIL LISTS

Foraminifera identified from the Eagle Ford group:

Haplophragmoides aff. *calcula* Cushman and Waters
Ammobaculites aff. *subcretacea* Cushman and Alexander
Spiroplectammina terquemi (Berthelin)
Verneuilina aff. *propinqua* H. B. Brady
Vaginulina webbervillensis Carsey
Vaginulina hebronensis Moreman
Frondicularia cordai Reuss
Guembelina globulosa (Ehrenberg)
Ventilabrella eggeri Cushman
Bulimina aff. *elegans* d'Orbigny
Bulimina aff. *murchisoniana* d'Orbigny
Loxostoma tegulatum (Reuss)
Gaudryina filiformis Berthelin
Quinqueloculina stelligera Schlumberger
Trochammina diagnosis (Carsey)
Lenticulina rotulata Lamarck
Marginulina elongata d'Orbigny
Dentalina communis d'Orbigny
Dentalina adolphina d'Orbigny
Bolivina sp.
Entosolenia sp.
Globigerina cretacea d'Orbigny
Globigerina voluta White
Hastigerinella moremani Cushman
Globotruncana arca (Cushman)
Gyroidina depressa (Alth)
Valvulineria aff. *asterigerinoides* Plummer
Anomalina eaglefordensis Moreman

Ostracoda identified from the Eagle Ford group:

Cythereis eaglefordensis Alexander
Bairdia alexanderina Blake
Cytherella munsteri (Roemer)
Cytheropteron n. sp. Alexander
Cythereis n. sp. Alexander

Megafossils of the Tarrant formation:

Exogyra columbella Meek (1876)
Inoceramus sp.
Acanthoceras aff. *rotomagense* (Defrance) (Adkins, 1928)
Acanthoceras inaequiplicatum (Shumard) (1860)
Acanthoceras aff. *turneri* White
Acanthoceras wintoni Adkins
Acanthoceras aff. *hunteri* Kossmat
Acanthoceras validum Moreman, n. sp.
Acanthoceras aff. *sherborni* Spath
Acanthoceras bellense Adkins
Acanthoceras stephensoni Adkins
Acanthoceras aff. *cunningtoni* (Sharpe)
Acanthoceras aff. *cunningtoni* var. *cornutum* Kossmat

Acanthoceras lonsdalei Adkins
Acanthoceras pepperense Moreman, n. sp.
Acanthoceras alvaradoense Moreman, n. sp.
Turrilites aff. *costatus* Lamarck
Turrilites aff. *desnoyersi* d'Orbigny
Metoicoceras swallovi (Shumard)
Epengonoceras dumbli (Cragin)

Megafossils of the Britton formation:

Nucula serrata Shumard (1860)
Nucula bellastriata Shumard (1862)
Nucula haydeni Shumard (1860)
Yoldia septarina Cragin (1893)
Cucullea millestriata Shumard (1862)
Gervillea gregaria Shumard (1860)
Inoceramus capulus Shumard (1860)
Inoceramus fragilis Hall and Meek (Meek, 1876)
Inoceramus labiatus Schlotheim (Stanton, 1893)
Inoceramus spp.
Ostrea anomiaeformis Roemer (Adkins, 1928)
Ostrea congesta Conrad (Adkins, 1928)
Phacoides sublenticularis Shumard (1860)
Veniella laphami (Shumard) (1862)
Crassatellites parvula Shumard (1862)
Cardium choctawense Shumard (1860)
Isocardia humilis Cragin (1893)
Venus sublamellosus Shumard (1860)
Meretrix lamarensis Shumard (1860)
Tapes hilgardi Shumard (1860)
Corbula graysonensis Shumard (1860)
Corbula tuomeyi Shumard (1860)
Panope subparallela Shumard (1860)
Epitonium ? lamarensis (Shumard) (1862)
Epitonium ? bicarinifera (Shumard) (1862)
Natica ? striaticosta Cragin (1893)
Anchura modesta Cragin (1893)
Acteon texana Shumard (1862)
Ringicula subpellucida Shumard (1862)
Ringicula acutispira Shumard (1862)
Eucalycoceras bentonianum (Cragin)
Eucalycoceras dentonense Moreman, n. sp.
Eucalycoceras indianense Moreman, n. sp.
Eucalycoceras lewisvillense Moreman, n. sp.
Tragodesmoceras scotti Moreman, n. sp.
Allocrioceras annulatum (Shumard)
Allocrioceras pariense (C. A. White)
Allocrioceras larvatum (Conrad)
Allocrioceras ? rotundatum (Conrad)
Allocrioceras dentonense Moreman, n. sp.
Metoicoceras whitei Hyatt
Metoicoceras gibbosum Hyatt
Metoicoceras acceleratum Hyatt
Metoicoceras irwini Moreman
Metoicoceras kanabense Hyatt
Metoicoceras ornatum Moreman, n. sp.
Barroisiceras trinodosum Moreman, n. sp.
Barroisiceras brittonense Moreman, n. sp.
Neocardioceras septem-seriatum (Cragin)
Worthoceras vermiculum (Shumard)
Worthoceras gibbosum Moreman, n. sp.
Scaphites brittonense Moreman, n. sp.
Scaphites minutus Moreman, n. sp.
Baculites gracilis Shumard
Protengonoceras planum Hyatt
Epengonoceras acutum (Hyatt)
Proplacenticeras cumminsi (Cragin)
Proplacenticeras pseudoplacenta var. *occidentale* (Hyatt)
Proplacenticeras stantoni var. *bolli* (Hyatt)

Megafossils of the Arcadia Park formation:

Inoceramus dimidius White (Stanton, 1893)
Alectryonia lugubris (Conrad) (Adkins, 1928)
Cyprimeria crassa Meek (1893)
Cyprimeria shumardi Cragin (1893)
Lingula shumardi Cragin (1893)
Romaniceras sp.
Prionotropis graysonensis (Shumard)
Prionotropis aff. *woolgari* Meek (not Mantell)
Prionotropis hyatti Stanton
Prionocyclus novi-mexicanus (Marcou)
Scaphites pygmaeus Morrow
Scaphites arcadiensis Moreman, n. sp.
Coilopoceras aff. *eaglefordense* Adkins
Coilopoceras colleti Hyatt

DESCRIPTION OF LOCALITIES

Locality no. 1.—The Tarrant formation can be found 2.25 miles east of Tarrant, Texas, railway station (measured along the railroad tracks) just north of the second railroad trestle on a small tributary of the Trinity River. The lower blue Britton clay is exposed in a cut immediately east of this locality. In a previous article the writer incorrectly located this exposure 1 mile east of Tarrant, Texas.

Locality no. 2.—The Tarrant formation is exposed 4 miles south of Alvarado, Texas (starting from the east side of the square) on the east side of the Waco highway.

Locality no. 3.—Tarrant formation exposures are known both north and south of the Belton-Temple highway where the highway crosses Pepper Creek.

Locality no. 4.—The Tarrant formation outcrops 4 miles east of Whitesboro, Texas, 0.25 mile south of the Whitesboro-Sherman highway.

Locality no. 5.—Britton formation can be seen 0.5 mile east of the Britton-Midlothian highway 2.7 miles south of the Britton, Texas, railway station in small ravines cut in the westward facing slope.

Locality no. 6.—Britton formation is exposed 4 miles south of the Britton, Texas, railway station on the Midlothian highway in a ravine east of the road.

Locality no. 7.—The Britton formation is exposed 100 yards east of the bridge on the Britton-Midlothian highway at a point 4.4 miles south of the Britton Railway station.

Locality no. 8.—An exposure of the Britton formation is present in a small ravine just south of the Lewisville-Hebron road 3.5 miles east of the Lewisville, Texas, railway station.

Locality no. 9.—Britton formation exposures are known in bluffs on Indian Creek 5.5 miles east of the Lewisville railway station on the Hebron road. One bluff is near the road on the south side, the other is 0.5 mile south of the road

Locality no. 10.—There is an exposure of the Britton formation in a small ravine 100 yards

north of the Prosper-Denton road 3 miles west of Prosper, Texas.

Locality no. 11.—The Britton formation outcrops 6 miles northwest of the central business block of Irving, Texas, or 3.2 miles north of Sowers, Texas, where a tributary of Hackberry Creek forms a low bluff on the east side of the road.

Locality no. 12.—The Britton formation is exposed 4.35 miles north of Sowers, Texas, where the Sowers-Coppell road turns right (east) 1 mile. The exposure is 0.5 mile north of the road on a tributary of Hackberry Creek.

Locality no. 13.—The Britton formation outcrops 3.4 miles southeast of Pottsboro, Texas, on the Whitesboro road.

Locality no. 14.—The Britton formation can be seen about 1.4 miles east of Carrollton, Texas, where there is an exposure on the north side of the road on Rawhide Creek.

Locality no. 15.—There is an exposure of the Britton formation on a tributary of Hackberry Creek about 0.25 mile west of the Hackberry-Irving road, 1 mile south of the intersection with the Dallas-Rhome highway.

Locality no. 16.—The Britton formation is exposed on the south bank of the Elm Fork of the Trinity River at the point where the railroad north out of Irving, Texas, crosses the river. The Dallas-Rhome highway crosses a short distance above this point. This locality was the site of Horton's Mill where most of Hyatt's species were collected.

Locality no. 17.—The Arcadia Park formation outcrops 1 mile south of Arcadia Park, Texas, in the flaggy limestone layers which form a low escarpment.

Locality no. 18.—The Arcadia Park formation is exposed about 75 feet below the base of the Austin chalk at White Rock scarp 2 miles west of Cedar Hill, Texas.

Locality no. 19.—A condensed section of the Arcadia Park formation was exposed in excavations for the Architectural building at the University of Texas.

DESCRIPTION OF SPECIES

Class PELECYPODA
Family PERNIDAE Zittel
Genus INOCERAMUS Sowerby
INOCERAMUS CAPULUS Shumard
Plate 31, figures 1, 3

Inoceramus capulus SHUMARD, *1860*, St. Louis Acad. Sci. Trans., I, p. 606.
Inoceramus capulus, ADKINS, *1928*, Texas Univ. Bull. 2838, p. 92.

Inoceramus capulus was not figured by Shumard, but the writer has a number of specimens which agree with his description almost exactly. The one here figured is being designated as the neotype and the original description is included since Shumard's work is not readily available.

Shumard's description.—

Shell subequivalve, elongate-ovate, section subordinate, antero-posterior diameter much shorter than from beak to base; umbonal region very gibbous; anterior slope falling abruptly to the margins, flattened above and more or less rounded below, margins sinuous; straight or slightly rounded posterior slope convex; anal margin rounded, forming with the cardinal an obtuse angle; base strongly arched; beaks terminal or nearly so, much elevated, curved forward, pointed; surface neatly ornamented with small, unequal, distinct concentric folds. In well preserved specimens, the umbo is marked with a few obscure, radiating ribs. The shell structure is made up of thin concentric laminae.

Length, 1 inch; height, 1.83 inches; thickness, about 1.5 inches.

Remarks.—The very gibbous umbonal region; anterior slope falling abruptly to the margins, flattened above and more or less rounded below; and obscure radiating ribs which extend back from the umbo for half the length of the shell are characteristic features. This species has been called *Inoceramus labiatus* Schlotheim by most paleontologists in Texas, but *labiatus* is thin and the surface is marked with regular coarse concentric lines of growth, separated by four to six smaller lines of growth. The specimen which is being designated as the neotype is considerably larger than the holotype, but in the description Shumard states that his collection contained fragments of large specimens. This specimen has a length of 40 mm., height of 75 mm., and thickness of one valve of 25 mm. The specimen is in an excellent state of preservation, includes both valves and retains most of the original shell.

Shumard states that *Inoceramus capulus* resembles *Inoceramus umbonatus* Meek and Hayden, but its height is greater, the opening of the valve is ovate instead of subcircular, the ornamentation is not so strongly developed, and it is not so strongly coiled. This species, so far as the writer has been able to determine, is found only in the Britton formation of north Texas.

Horizon.—Lower and middle parts of the Britton formation.

Locality of types.—Holotype: bluffs of Red River, Lamar County, Texas. Neotype: locality no. 10, Moreman collection, Bureau of Economic Geology, Austin, Texas.

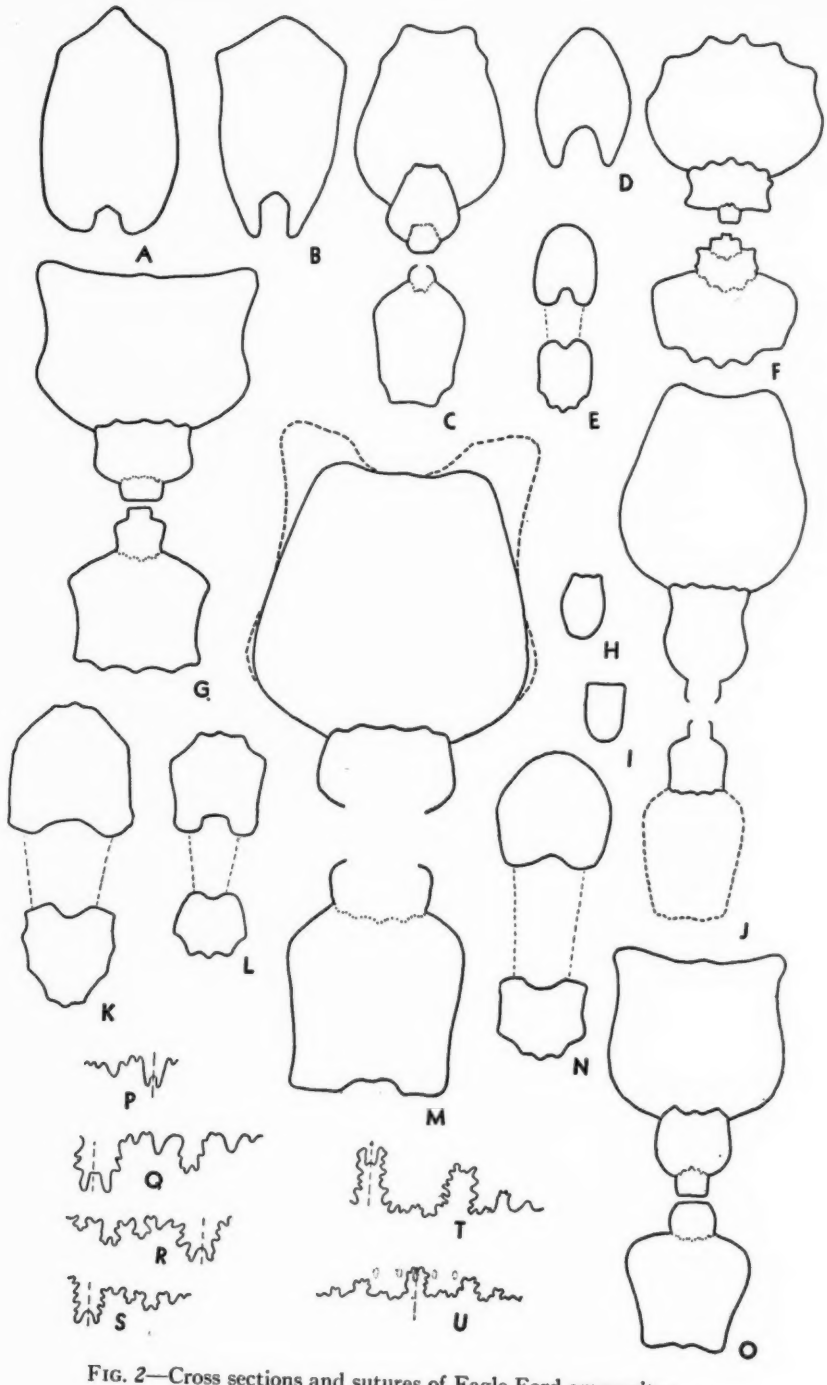


FIG. 2—Cross sections and sutures of Eagle Ford ammonites.

INOCERAMUS FRAGILIS Hall and Meek
Plate 34, figure 11

Inoceramus fragilis HALL and MEEK, *1854*, Am. Acad. Arts and Sci. Mem. (n. s.), 8, 388, pl. 2, fig. 6.
Inoceramus fragilis, STANTON, *1893*, U. S. Geol. Survey Bull. 106, p. 76, pl. 9, figs. 1–5.

The original description and figures were taken from an imperfect specimen, but later Meek (1876, p. 42) gave a description of a complete specimen from the type locality as follows:

Shell thin, broad-subovate, higher than long, moderately convex, subequivalve; anterior side vertically truncate from the beaks with a slightly concave outline; basal and posterior borders forming a more or less regular, nearly semicircular curve; hinge-line rather short, and standing nearly at right angles to the truncate anterior. Beaks pointed, equal, scarcely rising above the hinge, curving inward slightly forward at the points. Surface marked by fine lines of growth, and a few obscure traces of concentric undulations.

Height, about 1.43 inches; length, 1.07 inches.

Remarks.—Hill records *Inoceramus fragilis* from the Eagle Ford, but his figure was taken from Meek; thus the exact nature of his material is unknown. A number of excellently preserved specimens have been collected in north Texas which agree with Meek's description. Some of the Texas specimens, however, show variations, particularly in the development of the beak, which is not so elongate as in the typical form; also the concentric undulations are narrower and more uniform. The specimen here figured has a length of 70 mm.; width of 45 mm.; and thickness of one valve of 15 mm. *Inoceramus fragilis* occurs abundantly and usually in an excellent state of preservation.

Horizon.—Upper Britton formation.

Locality.—No. 9.

Figured specimen.—Moreman collection, Bureau of Economic Geology, Austin, Texas.

INOCERAMUS LABIATUS (Schlotheim)
Plate 31, figure 4

Ostracites labiatus SCHLOTHEIM, *1813*, Bronnis Jahrb., vol. 7, p. 93.
Inoceramus labiatus STANTON, *1893*, U. S. Geol. Survey Bull. 106, p. 77, pl. 10, fig. 4; pl. 14, fig. 2. (Synonomy to 1893.)
Inoceramus labiatus, HILL, *1901*, U. S. Geol. Survey 21st Ann. Rept. pl. 40, figs. 1, 3.
Inoceramus labiatus, ADKINS, *1928*, Texas Univ. Bull. 2838, p. 94. (Synonomy from 1911 to 1927.)

Remarks.—This species is thin, elongate-ovate in outline, beaks quadrate; the axis of the shell is at 45 degrees to the hinge line, and the sculpture consists of regular linguiform concentric undulations on which are imposed finer growth lines.

Inoceramus labiatus is known from the lower Turonian of Europe, and in the United States it occurs in beds of equivalent age. This species is not present in as great abundance in the Eagle Ford as was once

EXPLANATION OF TEXT FIGURE 2

A. Barroisiceras trinodosum, n. sp., ×½. (p. 212)
B. Barroisiceras brittonense, n. sp., ×½. (p. 212)
C. Metoicoceras ornatum, n. sp., ×½. (p. 211)
D. Tragodesmoceras scotti, n. sp., ×½. (p. 208)
E. Eucalycoceras bentonianum (Cragin), ×½. (p. 207)
F. Neocardioceras septem-seriatum (Cragin), ×½. (p. 213)
G. Acanthoceras aff. *sherborni* Spath, ×½. (p. 203)
H. Allocrioceras dentonense, n. sp., ×½. (p. 209)
I. Allocrioceras larvatum (Conrad), ×½. (p. 208)
J. Acanthoceras validum, n. sp., ×½. (p. 203)
K. Eucalycoceras dentonense, n. sp., ×½. (p. 205)
L. Eucalycoceras indianense, n. sp., ×½. (p. 206)
M. Acanthoceras pepperense, n. sp., ×½. (p. 204)
N. Eucalycoceras lewisvillense, n. sp., ×½. (p. 206)
O. Acanthoceras alvaradoense, n. sp., ×½. (p. 205)
P. Worthoceras vermiculum (Shumard), magnified. (p. 214)
Q. Worthoceras gibbosum, n. sp., magnified. (p. 215)
R. Scaphites brittonensis, n. sp., magnified. (p. 215)
S. Scaphites minutus, n. sp., magnified. (p. 216)
T. Acanthoceras alvaradoense, n. sp., ×½. (p. 205)
U. Eucalycoceras lewisvillense, n. sp., ×½. (p. 206)

thought, because other forms have been confused with it. The sculpture of this species is characteristic and should not be confused with any other. The specimen figured is rather poorly preserved but it is a typical form. The measurements are: length, 50 mm.; height, 25 mm.; and thickness of one valve, 5 mm.

Horizon.—Lower and middle parts of the Britton formation.

Locality.—No. 13.

Figured specimen.—Moreman collection, Bureau of Economic Geology, Austin, Texas.

INOCERAMUS DIMIDIUS White
Plate 31, figures 2, 6

Inoceramus dimidius WHITE, *1874*, Expl. and Survey 100th meridian, Preliminary Rept. Invertebrate Fossils, p. 25;——*1876*, U. S. Geog. and Geol. Survey, W. of 100th Mer. vol. 4, p. 181, pl. 16, figs. 2 a–d.
Inoceramus dimidius, STANTON, *1893*, U. S. Geol. Survey Bull. 106, p. 78, pl. 10, figs. 5, 6 (synonomy to 1893).

Shell small, inflated; valves subequal; beaks small, prominent and pointing a little forward; hinge line straight but rather short; shell marked by strong, regular concentric folds and fine lines of growth.

This species is characterized by its small size, prominent pointed beak and prominent ornamentation. The Texas species are slightly larger than those described from the interior by Stanton, averaging about 3–4 cm. in greatest length.

Horizon.—Arcadia Park formation, associated with *Prionotropis*, *Prionocyclus*, etc.

Locality—No. 16.

Figured specimen.—Moreman collection, Bureau of Economic Geology, Austin, Texas.

INOCERAMUS sp. 1
Plate 31, figure 5

Because of the vast amount of literature on the Inocerami no attempt has been made to describe new species.

This species resembles *Inoceramus deformis* Meek in the appearance of the ornamentation but differs in the shape of the outline and position of the beaks. The beaks in the latter species are not at right angles to the hinge line.

Horizon.—Britton formation in association with *Metoicoceras whitei* Hyatt.

Locality.—No. 14.

Figured specimen.—Moreman collection, Bureau of Economic Geology, Austin, Texas.

INOCERAMUS sp. 2
Plate 33, figure 13

This species resembles *Inoceramus proximus* Tuomey in general outline and ornamentation but differs in that the hinge line is longer and directed at a smaller angle with the longer axis of the shell.

Horizon.—Britton formation.

Locality.—No. 15.

Figured specimen.—Moreman collection, Bureau of Economic Geology, Austin, Texas.

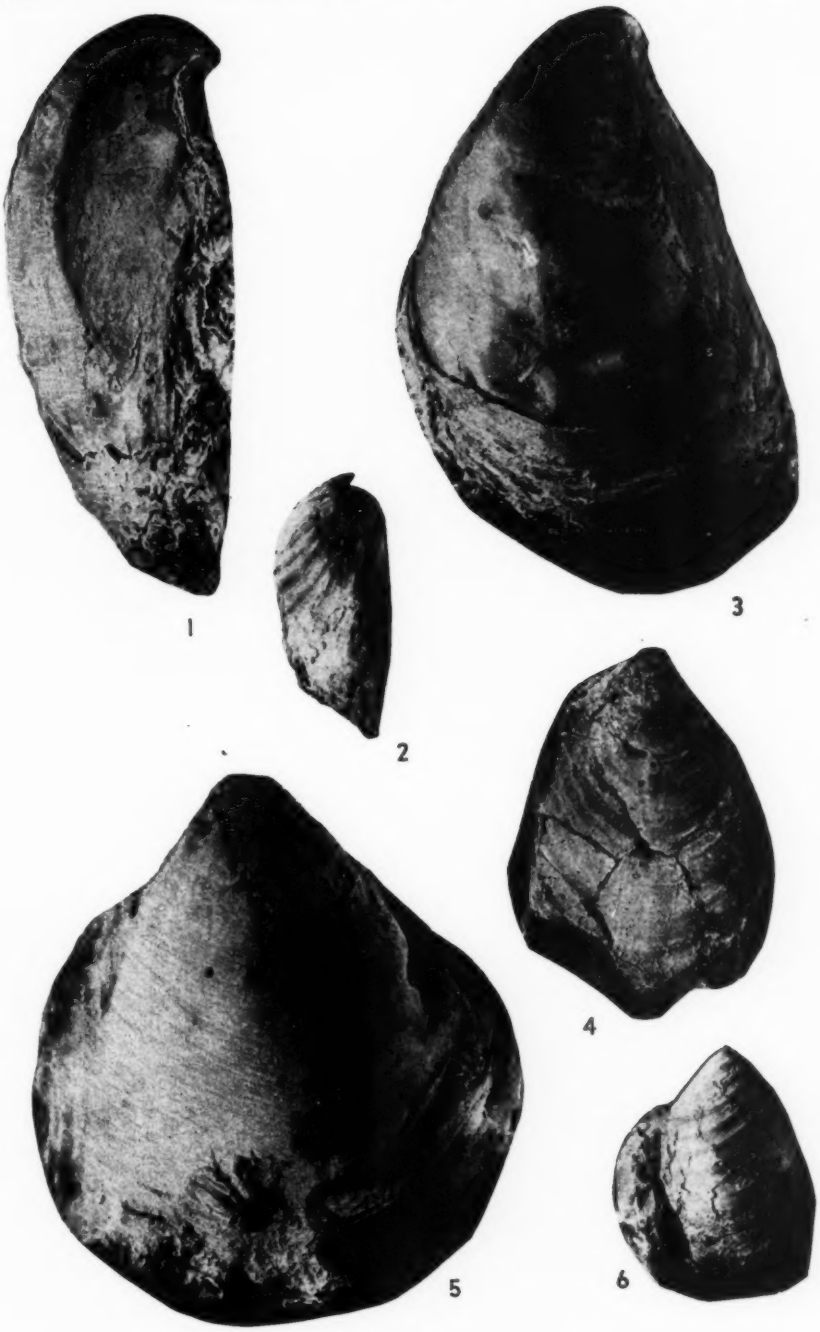
Class CEPHALOPODA
Order AMMONOIDEA
Family ACANTHOCERATIDAE
Genus ACANTHOCERAS Neumayr

The genotype, *Acanthoceras rotomagense* (Defrance), is of medium size, whorl quadrate in cross-section, and ornamented with relatively prominent ribs which bear five rows of tubercles on the ventral surface.

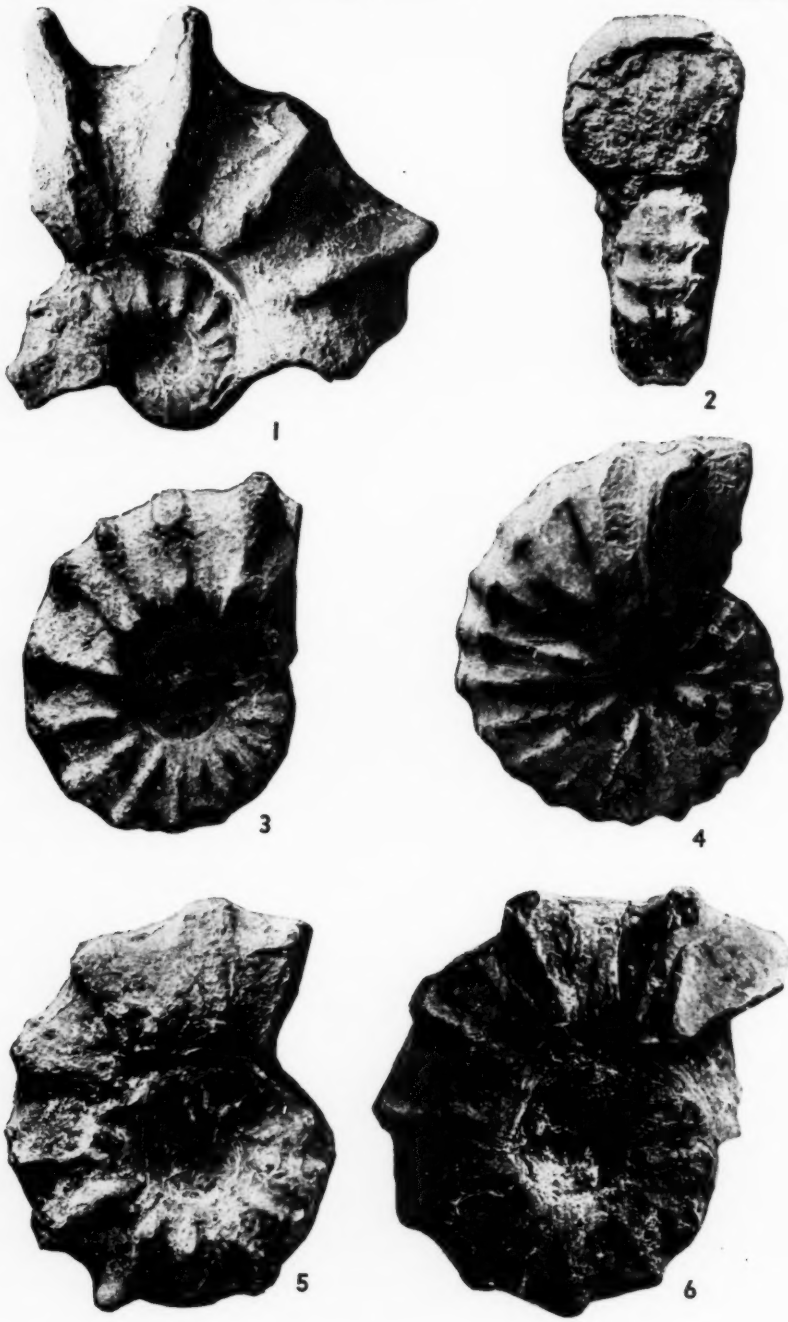
Various ammonite species have been placed at one time or another in this genus. During the last few years a number of new genera have been proposed for the family *Acanthoceratidae*, so it is now possible to classify the species of this family more accurately; and many of the species formerly classified as *Acanthoceras* belong to other genera of the same family. Kossmat placed all the species recognized in 1895 as *Acanthoceras* into seven groups (1895, p. 1, pt. 4). Many of these species, however, are now known to belong to such genera as *Mammites*, *Mantelliceras*, *Eucalycoceras*, *Romaniceras*, etc., so it is impossible to use his

EXPLANATION OF PLATE 31

FIGS. *1, 3—Inoceramus capulus* Shumard, neotype, ×1. (p. 197)
2, 6—Inoceramus dimidius White, hypotype, ×1. (p. 200)
4—Inoceramus labiatus Schlotheim, hypotype, ×1. (p. 199)
5—Inoceramus sp. 1, ×1. (p. 200)



Moreman, Upper Cretaceous Pelecypods



Moreman, Upper Cretaceous Ammonites

grouping for the species from the Tarrant formation.

The numerous species now properly placed in the genus *Acanthoceras* show many variations in ornamentation, particularly in the size, shape, and arrangement of the tubercles; but all resemble the typical form in their early stages. The species from the Tarrant formation may be roughly grouped as follows:

Group I.—Cross-section of whorl quadrate; ribs strong, extending from umbilicus across venter, each bearing five ventral tubercles of relatively uniform size, which vary in shape from conical to bullate, being reduced on last few ribs in some species.

Acanthoceras aff. *rotomagense* (Defrance)
Acanthoceras inaequiplicatum Shumard
Acanthoceras aff. *turneri* White
Acanthoceras wintoni Adkins

Group II.—Cross-section of last whorl higher than wide; ribs very strongly developed on last whorl, especially across the venter, and devoid of tubercles, early portion with five rows of tubercles.

Acanthoceras aff. *hunteri* Kossmat
Acanthoceras validum Moreman, n. sp.

Group III.—Cross-section of whorl subcircular; ribs prominent on last whorl, extending across venter and tending to develop laterally projecting tubercles, which give the venter a flat appearance; five rows of tubercles on the early portion, the outer-ventral and ventrolateral rows are paired, being joined by a low ridge; in some species the median tubercles are more numerous than the outer-ventral and ventrolateral.

Acanthoceras aff. *sherborni* Spath
Acanthoceras bellense Adkins
Acanthoceras stephensoni Adkins

Group IV.—Cross-section of whorl quadrate; ribs and tubercles usually strong, irregular in their development, and showing various types of specialization, the ventrolateral tubercles being in most cases large and extending laterally.

Acanthoceras aff. *cunningtoni* (Sharpe)
Acanthoceras aff. *cunningtoni* var. *cornutum* Kossmat
Acanthoceras lonsdalei Adkins
Acanthoceras pepperense Moreman, n. sp.

Group V.—Cross-section of the last whorl subcircular; early portion with five rows of tubercles; low keel developed on first part of last whorl, outer ventral tubercles obscure but ventrolateral tubercles prominent and longitudinally elongate; toward the aperture the ventrolateral tubercles are replaced by laterally projecting conical tubercles which are joined across the venter giving it a flat apperance.

Acanthoceras alvaradoense Moreman, n. sp.

ACANTHOCERAS aff. ROTOMAGENSE (Defrance)

Ammonites rotomagense DEFRANCE, *1882*, in CUVIER and BRONGNIART, Descr. Geol. Environs de Paris, p. 391, pl. 6, figs. 2 a–b

Several specimens collected in Bell County have the general features of this species. Cross-section of whorl quadrate; ribs strong, extending from umbilicus across venter, each bearing five ventral tubercles in both young and adult stages.

Horizon.—Tarrant formation.

Locality.—No. 3.

Adkins collection, Bureau of Economic Geology, Austin, Texas.

ACANTHOCERAS INAEQUIPLICATUM (Shumard) Plate 32, figure 2

Ammonites inaequiplicatus SHUMARD, *1860*, Acad. Sci. St. Louis Trans., I, p. 591.
Buchiceras inaequiplicatus CRAGIN, *1893*, Texas Geol. Survey Ann. Report, no. 4, pp. 233–234.
Acanthoceras rotomagense Scott, *1926*, Amer. Assoc. Petroleum Geologist Bull., vol. 10, p. 621, pl. 22, fig. 1.
Acanthoceras rotomagense, MOREMAN, *1927*, Jour. Paleontology, vol. 1, p. 92, pl. 13, fig. 1.
Metacalycoceras tarrantense ADKINS, *1931*, Texas Univ. Bull. no. 2838, pp. 241–242, pl. 28, fig. 3; pl. 29, fig. 1.

EXPLANATION OF PLATE 32

FIGS. *1*—*Acanthoceras validum*, n. sp., holotype, ×½. (p. 203)
2—*Acanthoceras inaequiplicatum* Shumard, neotype, ×½. (p. 201)
3—*Acanthoceras* aff. *sherborni* Spath, ×½. (p. 203)
4—*Metoicoceras ornatum*, holotype, n. sp., ×½. (p. 211)
5—*Acanthoceras pepperense*, n. sp., ×½. (p. 204)
6—*Acanthoceras alvaradoense*, holotype, n. sp., ×½. (p. 205)

This species, described by Shumard from the basal Eagle Ford, collected at Garret's Bluff on Red River, Fannin County, has been ignored in recent publications. Cragin, in 1893, described it as *Buchiceras inaequiplicatus* on the basis of specimens collected from the base of the Eagle Ford at an exposure on a small creek 1 miles east of Tarrant, Texas. This is the locality from which the specimen described by Adkins as *Metacalycoceras tarrantense* was collected. Neither Shumard nor Cragin figured *Acanthoceras inaequiplicatum*, but each gave a very accurate and scientific description with which the specimens figured by Scott and Adkins agree almost exactly. Since the specimen referred to by Scott as *Acanthoceras rotomagense* was the first to be figured, and since the type is apparently lost, it should be designated as the neotype.

For convenience the original description by Shumard is here included:

Shell large, gibbous, sides rounded; dorsum flat or very slightly convex; volutions four, partially embracing; umbilicus deep, less than the width of the last volution, exhibiting about one-half of each of the inner coils; aperture transverse, subreniform; surface of body volution ornamented with from 25–28 very prominent, unequal, rounded costae, some arising rather abruptly from the margin of the umbilicus, and others a short distance exterior to the latter—all of them being continued over the dorsum, at the margins of which they become obtusely angulated. Each rib bears two moderately distinct nodes, which are situated at their dorsal angles. In mature shells, the ribs of the anterior portion of the last volution are considerably narrower than the spaces between them, while posteriorly the ribs and spaces are about equal; aperture transverse, reniform.

Chambers divided into two lobes on either side; dorsal lobe as wide and longer than the superior lateral, composed of three principal, narrow branches on each side, and one or more short points in the intervals, the terminal branches bearing six or seven short points, the middle lateral ones four or five, and those at the base either simple or with one or two points; dorsal saddle double the width of the dorsal lobe, divided into two unequal lobes by a small auxiliary lobe, which is marked with several small points; superior lateral lobe oblique, its extremity furnished with four slender branches, each bearing several small points.

Diameter 5 inches, width of last volution 2 inches, thickness 2.8 inches.

Remarks.—Acanthoceras inaequiplicatum is very closely related to *Acanthoceras rotomagense* (Defrance) in its general sculpture and appearance. It differs from the latter species in that the tubercles, especially the mid-ventral row, are more obscure on the ribs of the living chamber, and the ribs are sharper. The shape and sculpture of the earlier portion is almost identical with that of *Acanthoceras rotomagense.*

Horizon.—Tarrant formation.

Locality.—No. 1.

Neotype.—Geology museum, Texas Christian University, Fort Worth, Texas.

ACANTHOCERAS aff. TURNERI White

Acanthoceras turneri WHITE, *1889*, U. S. Geol. Survey Bull. no. 51, p. 26, pl. 5, figs. 1, 2.
Acanthoceras aff. *turneri* ADKINS, *1928*, Texas Univ. Bull. 2838, p. 246, pl. 30, figs. 3, 4.

The specimen collected from the Tarrant formation resembles the original species very closely. It has moderately compressed volutions, numerous ribs which cross the venter, each bearing five tubercles, the midventral one becoming more or less obscure in the adult stage.

Horizon.—Tarrant formation.

Locality.—No. 3.

Hypotype.—Adkins collection, Bureau of Economic Geology, Austin, Texas.

ACANTHOCERAS WINTONI Adkins

Acanthoceras wintoni ADKINS, *1928*, Texas Univ. Bull. 2838, pp. 243–244, pl. 25, figs. 2, 3.

The whorl of this species is somewhat compressed, the last volution rapidly increasing in height; surface marked by radial ribs roughly alternate in length on last volution; on the early part of the last volution tubercles of the median row are low and longitudinally elongate, forming a discontinuous keel, tubercles of the outer ventral row are prominent and longitudinally elongate, causing the venter to be excavated, the ventrolateral tubercles are lower and more rounded; on the later portion of the last volution the median tubercles are obscure and the others are lower so that the venter is more rounded.

Horizon.—From (upper Woodbine) Tarrant formation.

Locality.—No. 1.

Holotype.—Adkins collection, Bureau of Economic Geology, Austin, Texas.

ACANTHOCERAS aff. HUNTERI Kossmat

Acanthoceras hunteri KOSSMAT, *1898*, Südind-Kreideform. Beitr. Paläontologie Oesterr.. Ungarns u. des Orients, 11. p. 9, taf. 3, fig. 4.

One fragmentary specimen which consists of a portion of the living chamber has features very similar to *A. hunteri*. Whorls considerably more compressed than in other species of this genus; surface marked by relatively numerous ribs, which become slightly higher as they cross the venter; tubercles obscure.

Horizon.—Tarrant formation.

Locality.—No. 3.

Hypotype.—Adkins collection, Bureau of Economic Geology, Austin, Texas.

ACANTHOCERAS VALIDUM Moreman, n. sp.
Plate 32, figure 1; text figure 2j

This species is based upon a single cast which has about one-third of the last whorl missing. Most of the living chamber, and all of the early whorls are well preserved.

The shell was a little more than medium size; last whorl elevated, inflated and very slightly more involute; venter rounded in early portion, flat on penultimate and beginning of last whorl, rounded on living chamber; cross-section of whorl quadrate; umbilicus very broad, being about one-third the total diameter.

Measurements: Diameter, 250 mm.; height of last whorl above venter, 102 mm.; width of last whorl, 100 mm.; height of penultimate whorl, 40 mm.; width of penultimate whorl, 38 mm.; width of umbilicus, 85 mm.

Surface marked by ribs which in the early portion are low, straight and numerous, but gradually become more prominent and widely spaced, being about 40 mm. apart on the living chamber; venter on the early portion is marked by a low median keel; ventrolateral margin bears an inner and outer row of small rounded tubercles, from each outer tubercle a rib extends straight across the flanks to the umbilical wall, being prominent on the umbilical shoulder, where they are transversely elongate; on the beginning of the last whorl, where the venter is flat, there is a low keel, an inner row of bullate tubercles joined by a low connection to the outer row, which is taller and projects laterally; ribs on living chamber are more prominent and extend across the venter, gradually becoming higher from the umbilical shoulder to the venter, where they are 30 mm. high; keel is absent, and there is only a slight indentation between the outer row of tubercles.

Suture conspicuously denticulate, consisting of a long siphonal and two lower lateral lobes, the third narrower than the second. The first lateral saddle is broad and bifid, while the second and third are simple but denticulate.

Remarks.—This species differs from *Acanthoceras hunteri*, which it more closely resembles than any other, in having stronger and more widely spaced ribs, and in having the cross-section of the last whorl thicker in proportion to the height.

Horizon.—Tarrant formation.

Locality.—No. 3.

Holotype.—Adkins collection, Bureau of Economic Geology, Austin, Texas.

ACANTHOCERAS aff. SHERBORNI Spath
Plate 32, figure 3; text figure 3.

Ammonites cenomanensis SHARPE (not Gueranger), *1853*, Pal. Soc. London, p. 31, pl. 27, fig. 1.

Acanthoceras sherborni SPATH, *1926*, Geol. Mag. vol. 42, pp. 77–83.

This species is rather abundant in the Tarrant formation of Bell County. It is characterized by having rather prominent ribs, which bear five rows of tubercles on the younger whorls, the two outer rows joined by a low ridge forming pairs on the shoulders; on the latter portion the ribs extend square across the venter and tend to develop prominent laterally projecting tubercles.

Horizon.—Tarrant formation.

Locality.—No. 3.

Figured specimen.—Adkins collection, Bureau of Economic Geology, Austin, Texas.

ACANTHOCERAS BELLENSE Adkins

Acanthoceras bellense ADKINS, *1928*, Texas Univ. Bull. no. 2838, pp. 245–246, pl. 30, figs. 1, 2.

Medium size, robust, volutions quadrate in cross-section; umbilicus slightly less than one-third the total diameter. Ribs straight or slightly flexuous, slightly elevated near umbilicus. Paired ventrolateral tubercles,

unequal, longitudinally elongate, connected by a low ridge; median row of tubercles low.

Horizon.—Tarrant formation.

Type locality.—No. 3.

Holotype.—Bureau of Economic Geology, Austin, Texas. Adkins collection.

Acanthoceras stephensoni Adkins

Acanthoceras stephensoni Adkins, *1928*, Texas Univ. Bull. no. 2838, p. 246, pl. 31, figs. 1, 2.

This species resembles the two preceding in general sculpture, but it is more robust, the whorls being exceedingly thick. The paired shoulder tubercles are very prominent, and the median tubercles are low and longitudinally elongate. The living chamber of the holotype was not preserved, but another specimen from the same locality shows that the ribs extend flat across the venter.

Horizon.—Tarrant formation.

Type locality.—No. 3.

Holotype.—Bureau of Economic Geology, Austin, Texas. Adkins collection.

Acanthoceras aff. cunningtoni (Sharpe)

Ammonites cunningtoni Sharpe, *1854*, Pal. Soc. London Mon. 8, p. 35, pl. 15, fig. 2.

Several specimens from Bell County resemble this species almost exactly. On the later portion of the last whorl the ventrolateral tubercles are very prominent, and the two are separated by a deep median excavation. There is a slight variation in the arrangement of the tubercles on the early portion of the last whorl, the outer ventral tubercles are not so longitudinally elongate.

Horizon.—Tarrant formation.

Locality.—No. 3.

Hypotype.—Adkins collection, Bureau of Economic Geology, Austin, Texas.

Acanthoceras aff. cunningtoni var. cornutum Kossmat

Acanthoceras cunningtoni var. *cornutum* Kossmat, *1898*, Beitr. Paläontologie Oesterr.-Ungarns u. des Orients, II, p. 18, pl. 5, fig. 1.

One specimen collected at the Bell County locality closely resembles this variety. The prominent transversely elongate tubercles on the last portion of the living chamber, separated by a deep median excavation, seem to be characteristic of this species. The tubercles on the early portion have about the same arrangement as those of the type specimen, there being a greater number in the midventral row than in the others.

Horizon.—Tarrant formation.

Locality.—No. 3.

Hypotype.—Adkins collection, Bureau of Economic Geology, Austin, Texas.

Acanthoceras lonsdalei Adkins

Acanthoceras lonsdalei Adkins, *1928*, Texas Univ. Bull. no. 2838, p. 244, pl. 26, fig. 5; pl. 27, fig. 3.

This species is very closely related to the preceding species especially in the development of the median row of ventral tubercles. It seems to be characterized by having the ribs more crowded and less prominent tubercles in the later stages.

Horizon.—Tarrant formation.

Type locality.—No. 3.

Holotype.—Bureau of Economic Geology, Austin, Texas. Adkins collection.

Acanthoceras pepperense Moreman, n. sp.

Plate 32, figure 5; text figure 2m

This species is based upon a cast which is complete except for a small portion of the last whorl. Medium size; inflated, whorl nearly circular in cross-section; only slightly involute; venter rounded between ribs, concave between ventrolateral tubercles; flanks convex; umbilicus broad, being about one-third the diameter.

Venter rounded; surface marked by ribs which are low in the earlier portion but gradually become more prominent and widely spaced, being about 20 mm. apart on the last part of the living chamber; each rib continues in full development to the umbilicus and bears a rather large and prominent tubercle on the umbilical shoulder; on the beginning of the last whorl the venter is rounded, bearing a low keel, an outer row of ventral tubercles joined by a low ridge to a row of slightly larger ventrolateral tubercles; on the later portion the keel is obscure, and only the ventrolateral tubercles persist, greatly enlarged, transversely elongate, and separated by a ventral excavation. Suture not observed.

Measurements: Diameter, 175 mm.; umbilicus, 60 mm.; height of last whorl above

venter, 60 mm.; width of last whorl, 67 mm.; height of penultimate whorl, 38 mm.; width of penultimate whorl, 42 mm.

Remarks.—The arrangement of the ventrolateral tubercles in the later stages would suggest that of *A. cunningtoni*, but in *A. pepperense* the ribs are heavier and have a rather prominent umbilical tubercle; also the midventral tubercles are fewer in number and elongated into a discontinuous keel.

Horizon.—Tarrant formation.

Locality.—No. 3.

Holotype.—Adkins collection, Bureau of Economic Geology, Austin, Texas.

ACANTHOCERAS ALVARADOENSE Moreman, n. sp.

Plate 32, figure 6; text figure 2o, t

This species is based upon a cast which is nearly complete.

Medium size; inflated; almost circular in cross-section; only slightly involute; venter rounded between ribs, flattened opposite lateral tubercles, excavated on first part of last whorl; flanks only slightly convex; umbilicus broad, about one-third the diameter.

On the inner whorl at a diameter of 25 mm. the surface is marked by straight ribs which cross the venter, each bearing a ventral, outer ventral, and ventrolateral tubercle. On the beginning of the last whorl there is developed a low keel; the outer ventral tubercles are obscure, and the ventrolateral tubercles are prominent and longitudinally elongate; toward the aperture the ventrolateral tubercles become more conical, are connected across the venter by two low ridges, the posterior one extending straight across while the anterior one makes a broad curve forward, and are 12 mm. high; the last two tubercles are joined by a higher ridge, making the venter almost flat between the tubercles; flanks of last whorl bear 11 straight ribs, which extend from the ventrolateral tubercles to the umbilicus, being more prominent just before the umbilical shoulder is reached.

Suture consists of a long siphonal lobe, a slightly shorter first lateral and a small second and third lateral lobes; first saddle broad and bifid, other three simple; sutures prominently denticulate.

Measurements: Diameter, 125 mm.; height of last whorl, 45 mm.; thickness of last whorl, 45 mm.; involution, 5 mm.; height of penultimate whorl, 25 mm.; thickness of penultimate whorl, 25 mm.; umbilicus, 40 mm.

Remarks.—This species is characterized by the prominent ventrolateral longitudinally elongate tubercles on the first two-thirds of the last whorl. *Acanthoceras wintoni* Adkins has slightly bullate ventrolateral tubercles, but the ribs are more numerous and extend entirely across the venter at all stages.

Horizon.—Tarrant formation.

Locality.—No. 2.

Holotype.—Moreman collection, Bureau of Economic Geology, Austin, Texas.

Genus EUCALYCOCERAS Spath

EUCALYCOCERAS DENTONENSE Moreman, n. sp.

Plate 33, figure 4, 5; text figure 2k

This species is based upon a portion of the living chamber which has retained the outline of the last suture.

A little less than medium size; venter arched; flanks slightly convex; whorl in cross-section a very little taller than broad; slightly involute; umbilicus broad.

Twelve ribs on living chamber, well-developed, slightly inclined backward, pass entirely over the venter, meet in pairs on the umbilical shoulder to form six tubercles, of which the two posterior ones are much larger than the four anterior ones; ventral, outer ventral, and ventrolateral tubercles, which are low and blunt, appear on the posterior half of the living chamber, but become more indistinct anteriorly.

Suture poorly preserved; the distal portion of the three lateral lobes remain and show that they are broad with small, simple incisions and very likely are shallow. First lateral saddle imperfectly bilobate, middle one shows a slight tendency towards this character; two lateral lobes are very short and slender, the upper one being twice the size of the lower one; incisions are simple, shallow and few; siphonal lobe not preserved.

Measurements: Diameter, 79 mm.; greater radius, 34.8 mm.; lesser radius, 26 mm.; height of last whorl, 34.8 mm.; height of last whorl above venter, 32.5 mm.; thickness of last whorl, 31 mm.; width of umbilicus, 26 mm.

Remarks.—This species differs from *Eucalycoceras bentonianum* (Cragin) in having thicker ribs, all of which reach the umbilical shoulder or anastomose with the preceding rib just before the umbilicus is reached, whereas in the latter species the ribs alternate irregularly long and short. The tubercles are more prominent on *Eucalycoceras dentonense*, and are developed at a later stage. The cross-section of the whorl in *Eucalycoceras bentonianum* is higher in proportion to the width than in *Eucalycoceras dentonense.*

Horizon.—Middle Britton formation.

Locality.—No. 9.

Holotype.—Moreman, collection, Bureau of Economic Geology, Austin, Texas.

EUCALYCOCERAS INDIANENSE Moreman, n. sp.

Plate 33, figures 9, 10; text figure 21

Acanthoceras sp. *A* Moreman, *1927*, Jour. Paleontology vol. 1, p. 95, pl. 15, fig. 2.

This species is based on a portion of a single cast, consisting of the living chamber and only one adjoining chamber.

Less than medium size; inflated, whorl almost square in cross-section; venter arched; flanks almost flat; appears to have been only slightly involute; umbilicus broad.

Fourteen prominent ribs on the living chamber are slightly sigmoid on the flanks and pass straight across the arched venter, each rib having five tubercles, one midventral, two outer ventral, and two ventrolaterals; arrangement of ribs on the umbilical shoulder is irregular, some extending entirely to the umbilicus, where they bear prominent tubercles, others not reaching entirely to the umbilicus, while still others join two together forming prominent tubercles on the umbilical shoulder.

Suture poorly preserved. A very narrow siphonal lobe and two narrow lateral lobes; three broad, denticulated lateral saddles, the first being particularly broad.

Measurements: Diameter, 56.5 mm.; greater radius, 28.3 mm.; lesser radius, 19 mm.; height of last whorl, 28.3 mm.; height of last whorl above venter, 23.5 mm.; involution, 2.5 mm.; thickness of last whorl, 24 mm.; width of umbilicus, 18 mm.; suture taken at diameter of, 42 mm.

Remarks.—This species differs from the others described from the Eagle Ford in having slightly sigmoid ribs, nearly all of which reach the umbilical shoulder or anastomose on the flanks, and in having prominent tubercles on all the ribs. *Eucalycoceras leonense* has relatively prominent tubercles in the adult stage, but has straight ribs which alternate regularly long and short.

Horizon.—Middle Britton formation.

Locality.—No. 9.

Holotype.—Moreman collection, Bureau of Economic Geology, Austin, Texas.

EUCALYCOCERAS LEWISVILLENSE Moreman, n. sp.

Plate 33, figures 6, 7; text figure 2n, u

This species is based on a portion of a single cast, consisting only of the living chamber.

Less than medium size; whorl elevated; venter arched; flanks almost flat; slightly involute; umbilicus rather broad.

Fourteen rather prominent ribs on the living chamber, which pass entirely across the venter; the first nine of these ribs bear five tubercles, one mid-ventral, two outer ventral, and two ventro-laterals; these tubercles become increasingly less prominent on each succeeding rib, the ninth one only bearing traces of them; the remaining five ribs are entirely devoid of protuberances; arrangement of ribs on umbilical shoulder is irregular, some extending entirely to the umbilicus where they bear tubercles, others disappearing or anastomosing about three-fourths of the way down the flanks.

Suture a rather narrow siphonal lobe, and two smaller lateral lobes which bear simple denticulations. First lateral saddle is broad, and bifid and simply denticulated; second and third saddles are much smaller, and are single.

Measurements: Diameter, 77 mm.; height of last whorl, 31.5 mm.; width of last whorl, 25 mm.; involution, 3 mm.; width of umbilicus, 25 mm.

Remarks.—This species resembles *Eucalycoceras dentonense* in general features, but differs in having more closely spaced ribs which are devoid of tubercles on the later half of the living chamber. The cross-section is taller than wide. *Eucalycoceras lewisvil-*

lense differs from *Eucalycoceras bentonianum* in having stronger ribs which do not alternate in length.

Horizon.—Middle Britton formation.

Locality.—No. 9.

Holotype.—Moreman collection, Bureau of Economic Geology, Austin, Texas.

EUCALYCOCERAS LEONENSE Adkins

Eucalycoceras leonense ADKINS, *1928*, Texas Univ. Bull. no. 2838, pp. 240–241, pl. 28, fig. 1; pl. 29, fig. 3.

Small size; inflated; involute; umbilicus about one-fourth the total diameter; ribs somewhat elevated and narrowly rounded, of alternate lengths, the long one elevated at umbilical ends; each rib bears five tubercles, one on the mid-ventral line, one outer ventral, and one ventro-lateral on each side; the tubercles form three facets, one across the venter and one on each ventro-lateral margin. Suture unobserved.

Remarks.—This species is characterized by having straight ribs which alternate regularly long and short; and in having a relatively smaller umbilicus.

Horizon.—Tarrant formation.

Locality.—No. 3.

Holotype.—Bureau of Economic Geology, Austin, Texas. Adkins collection.

EUCALYCOCERAS BENTONIANUM (Cragin)
Text figure 2e

Pulchellia bentonianum CRAGIN, *1893*, Texas Geol. Survey Ann. Rept., no. 4, p. 239.
Eucalycoceras bentonianum ADKINS, *1931*, Texas Univ. Bull. no. 3101, p. 63.

The holotype of this species has been deposited in the museum of the Bureau of Economic Geology, Austin, Texas and the cross-section of the whorl is here figured. For convenience the original description is also included:

Shell rather small, discoid, composed of about four and one-half slightly embracing volutions; whorl sides flat-convex; venter rounded; body chamber comprising (?) half a volution, the outline of its cross-section higher than wide and much as in *P. pulchellus* d'Orbigny; surface of outer volution ornamented with prominent, transverse, narrowly compressed ribs that cross venter and all or part of the sides continuously, the longer ribs originating suddenly at the umbilical shoulder of the whorl and tending to alternate with one or two shorter ones; ribs more or less distinctly sex-tuberculate, becoming simple on the anterior part of the body-chamber; ribs about twice as widely interspaced as in *P. pulchellus*.

The sutural lines are not preserved, but the septum preceding the body chamber is sufficiently well exposed, by a break at that point, to indicate that there are but few saddles and leaves; apparently two (bi-lobate) saddles besides the (minute) auxiliaries, and corresponding leaves.

Of the tubercles of the ribs, there are on either side, one a little at one side of the ventral line, a second not far from it, ventro-lateral in position, and a third at the umbilical end or origin of the rib. The ribs on the posterior part of the body-chamber where the tubercles are well developed, are angulated by the four upper tubercles.

Measurements: Diameter of coil of type specimen (about) 57 mm.; transverse diameter of cross-section of body-chamber near aperture 17 mm.; vertical diameter of same section 20.5 mm.

Horizon.—Britton formation.

Type locality.—Hackberry Creek, Dallas County, Texas.

Holotype.—W. F. Cummins collection, Geological Survey of Texas, Bureau of Economic Geology, Austin, Texas.

Genus ROMANICERAS

ROMANICERAS sp.

Specimens which undoubtedly belong to this genus occur in the Arcadia Park formation near Austin, Texas; but the material is not available for description here.

Romaniceras has been reported from the Britton formation of north Texas but careful study of this material has proven that the specimens belong to the genus *Eucalycoceras*. The genus *Romaniceras* seems to occur more abundantly in the upper Turonian.

MANTELLICERAS SELLARDSI Adkins

Mantelliceras sellardsi ADKINS, *1928*, Texas Univ. Bull. no. 2838, pp. 239–240, pl. 25, fig. 1; pl. 26, fig. 4.

Small size; laterally compressed; umbilicus about one-fifth the total diameter; ribs of alternate length, cross venter as prominent rounded elevations; a pair of ventro-lateral tubercles, the outer one forming an angulation with the rib. Suture unobserved.

Horizon.—Tarrant formation.

Type locality.—Williamson County, about one-half mile southeast of Round Rock, Texas. (Adkins locality 2425)

Holotype.—Bureau of Economic Geology, Austin, Texas. Adkins collection.

Family DESMOCERATIDAE
Genus TRAGODESMOCERAS Spath
TRAGODESJOCERAS SCOTTI, n. sp.
Plate 33, figure 8; text figure 2d

This species is based upon a cast of which most of the earlier portion is missing.

A little less than medium size; discoid; involute; elevated and moderately inflated; the venter narrowly rounded; cross-section suboval; umbilicus small, being about one-eighth the diameter of the entire shell.

Surface ornamented with nine widely spaced, rounded ribs, which cross the venter uninterrupted and extend in about the same development almost to the umbilicus, devoid of nodes; ribs are approximately straight on the flanks, but flex anteriorly over the venter; on the venter the ribs are about 12 to 18 mm. apart, and in between there are numerous fine obscure ribs or striae which more or less parallel the larger ribs and are best seen in the region of the umbilicus.

Only the distal ends of the saddles are preserved. From these it appears that there is a siphonal lobe, and three lateral lobes, the first of medium size, and the other two small; there are four lateral saddles, the first of which is bifid with many fine dissections, the remaining three are small but finely dissected.

Measurements: Diameter, 66 mm.; greater radius, 36 mm.; lesser radius, 23 mm.; involution, 8 mm.; thickness of last whorl, 26 mm.; width of umbilicus, 7 mm.

Horizon.—Britton formation.

Locality.—No. 12.

Holotype.—Bureau of Economic Geology, Austin, Texas. Moreman collection.

Family PHLYCTICRIOCERATIDAE
Genus ALLOCRIOCERAS Spath
ALLOCRIOCERAS ANNULATUM (Shumard)

Ancyloceras annulatum SHUMARD, *1860*, Acad. Sci. St. Louis Trans., vol. I, p. 595.
Ancyloceras annulatum, WHITE, *1883*, U. S. Geol. Survey Terr. (Hayden) 12th Ann. Rept., pt. 1, p. 39, pl. 28, fig. 10.
Heliococeras pariense MOREMAN, *1927*, Jour. Paleontology, vol. 1, no. 1, pl. 14, fig. 3.

Numerous specimens have been collected from the Britton formation which agree with the description of this species given by Shumard.

Cross-section of whorl nearly circular; surface marked by many well-defined, oblique ribs, which completely encircle the shell but are less prominent on the dorsum than on the venter and sides; each rib bears a single small sharp tubercle on each ventrolateral margin, thus making the ribs appear flat across the venter.

Allocrioceras annulatum differs from *Allocrioceras pariense* in having finer and more closely spaced ribs, and in having a cross-section which is slightly higher in proportion to the width.

Horizon.—Britton formation.

Locality.—No. 5.

Type locality.—Shawnee Creek, Grayson County.

Characteristic specimen.—Moreman collection, Bureau of Economic Geology, Austin, Texas.

ALLOCRIOCERAS PARIENSE (C. A. White)

Helioceras pariense WHITE, *1876*, U. S. Geog. and Geol. Survey W. of 100th Meridian, vol. 4, p. 203, pl. 19, figs. 2 a–d.
Exiteloceras pariense, HYATT, Amer. Phil. Soc. Proc., 32, p. 577.
Exiteloceras pariense, ADKINS, *1928*, Texas Univ. Bull. no. 2838, p. 212, pl. 26, fig. 3.

This species has often been reported from the Eagle Ford of Texas, but never the less, is rather rare. The typical *Allocrioceras pariense* is characterized by having the surface marked by rather strong, abruptly rounded, simple ribs, each bearing a pair of relatively prominent tubercles on the venter.

One specimen in our collection possesses these characters, and no doubt belongs to this species.

Horizon.—Britton formation.

Locality.—No. 5.

Characteristic specimen.—Moreman collection, Bureau of Economic Geology, Austin, Texas.

ALLOCRIOCERAS LARVATUM (Conrad)
Text figure 2i

Hamites larvatus CONRAD, *1855*, Philadelphia Acad. Nat. Sci. Proc. 7, p. 265.
Hamites larvatus, CONRAD, *1857*, in W. H. Emory Rept. U. S. and Mex. Boundary Surv., vol. I, pt. 2, pl. 21, fig. 8.
Hamites larvatus, ADKINS, *1928*, Texas Univ. Bull. no. 2838, p. 209.

Conrad's description is as follows:

Ovate-oval, obliquely ribbed; back rounded, the opposite side truncated; ribs obsolete on the back, prominent and acute laterally, and increasing in elevation alternately towards the back, where they are truncated and form two series of slightly salient angles or tubercles; intermediate rib nearly equal in size, rounded on the submargin of the back entire. A cast.

Locality: Dallas County.

A specimen from the Academy of Natural Sciences of Philadelphia, no. 4790, now in the Bureau of Economic Geology, Austin, Texas, labeled *Hamites larvatus* Conrad, Dallas County, Texas has the following features:

Specimen consists of a cast of only a portion of the living chamber.

Cross-section of whorl ovate, only slightly higher than wide; ribs directed obliquely backward, prominent on venter but low and poorly defined on dorsum, alternate ribs have prominent ventrolateral tubercles which cause the rib to be flat across the venter, other ribs devoid of tubercles and rounded across venter.

Suture not preserved.

Measurements: Length of fragment, 38 mm.; height of fragment, 15 mm.; thickness of fragment, 11 mm.

Remarks.—This species is characterized by having relatively coarse and widely spaced ribs, tubercles on alternate ribs, and other ribs smooth.

Horizon.—Britton formation.

Type locality.—Dallas County.

ALLOCRIOCERAS? ROTUNDATUM (Conrad)

Hamites rotundatus CONRAD, *1855*, Acad. Nat. Sci. Philadelphia Proc. 7, p. 266.
Hamites rotundatus, ADKINS, *1928*, Texas Univ. Bull. no. 2838, p. 209.

This species described from Dallas County by Conrad is difficult to classify because of inadequate description and absence of figure. It no doubt came from the Britton formation, although the locality given is rather indefinite.

Conrad's description is as follows:

Rounded, ribs distant, acute, the intervening spaces regularly and profoundly concave; back flattened with the ribs obsolete and three indistinct longitudinal lines. A cast.

Locality: Dallas County.

ALLOCRIOCERAS DENTONENSE Moreman, n. sp.

Plate 34, figure 4; text figure 2h

This species is based upon a fragment of the last portion of the living chamber.

Small in size; fragment indicates that the shell was an open, unsymmetrical spire; dorsum rounded; venter only slightly rounded; cross-section of living chamber oval.

Measurements: Height of living chamber, 13 mm.; thickness, 10 mm.; length of fragment, 34 mm.

Fragment bears 11 prominent, moderately coarse ribs which encircle the entire shell; across the venter the ribs are almost flat, rising about 1 mm. high, and bearing on the ventrolateral margin a single prominent rounded tubercle; from the ventrolateral margin they extend obliquely backward and dorsally, and gradually decrease in prominence, until on the dorsum they are less than half as high as on the venter.

Suture not observed.

Remarks.—This species is larger and the cross-section of the whorl is considerably taller in proportion to the width than either *Allocrioceras pariense* or *Allocrioceras annulatum.*

Horizon.—Lower Britton formation.

Locality.—No. 8.

Holotype.—Moreman collection, Bureau of Economic Geology, Austin, Texas.

Family TURRILITIDAE Meek
Genus TURRILITES Lamark

Several specimens of Turrilites were collected by W. S. Adkins at exposures in Bell and Williamson Counties, but most of the material is so fragmentary that an exhaustive study of this group is not attempted by the writer. Two species identified by Adkins from the Tarrant formation of Bell County, *Turrilites* aff. *costatus* Lamark (Adkins, 1928, p. 215, pl. 24, fig. 7) and *Turrilites* aff. *desnoyersi* d'Orbigny (Adkins, 1928, p. 215, pl. 24, fig. 6), agree almost exactly in sculpture with published figures of European specimens of the same species, which occur in the upper Cenomanian. Continued collecting will no doubt reveal additional species of *Turrilites* in the Tarrant formation.

Locality.—No. 3.

Family BACULITIDAE
Genus BACULITES Lamark
BACULITES GRACILIS Shumard

Baculites gracilis SHUMARD, *1869*, Acad. Sci. St. Louis Trans., vol. 1, p. 596.
Baculites gracilis, ADKINS, *1928*, Texas Univ. Bull. no. 2838, pp. 206–207, pl. 24, fig. 3.

Small to large size; shell, except for the early coiled portion, straight and slender; cross-section subcircular in early portion, ornate in later portion; surface marked by ribs which in some cases are almost obscure, in other cases moderately prominent; on the specimen at hand, which measures 11.5 inches in length and consists of all of the living chamber, the ribs arch forward across the venter, extend obliquely backward and downward across the flanks and continue straight across the dorsum, where they are almost obscure; aperture, which is almost completely preserved, flares slightly and the ventral margin extends 20 mm. beyond the dorsal margin.

Suture, consists of five lobes and five saddles, both bifid, the lobes more finely denticulated; saddle divided by a single lobule.

Horizon.—Britton formation.

Type locality.—On Shawnee Creek, Grayson County.

Locality.—No. 5.

Hypotype.—Moreman collection, Bureau of Economic Geology, Austin, Texas. The holotype apparently was lost.

Family METOICOCERATIDAE Hyatt
Genus METOICOCERAS Hyatt

There have been five species of *Metoicoceras* described from the Eagle Ford group and there is one new species to be described. The genus ranges from the Tarrant formation through the Britton formation, and it comprises one of the most characteristic groups in regard to species and individuals. The members of this genus have a more or less compressed shell, elevated and involute. The venter is flat and there are characteristically two rows of lateral tubercles. The suture is characteristic, consisting of from five to six lobes and saddles, the siphonal and first lateral lobes being longest.

METOICOCERAS SWALLOVI (Shumard)

Metoicoceras swallovi SHUMARD, *1860*, Acad. Sci. St. Louis Trans., vol. 1, pp. 591–592.
Metoicoceras swallovi, HYATT, *1903*, U. S. Geol. Survey Mon. 44, p. 118, pl. 11, figs. 7–24; pl. 12, figs. 1, 2; pl. 15, figs. 1–4.

Characterized by having a relatively wide umbilicus, which is about one-fourth the total diameter; strong, longitudinally elongate tubercles; ribs strong with a pair of prominent ventrolateral tubercles; well-defined ventrolateral facet.

Suture with relatively broad and only moderately denticulate lobes, and very simple saddles.

Horizon.—Tarrant formation.

Locality.—(Type from Grayson County). Characteristic specimens have been collected by geologists of the U. S. Geological Survey at Slate Shoals, Red River, Lamar County.

A plaster cast of a characteristic specimen, sent to the writer by John B. Reeside Jr., has been deposited in the Bureau of Economic Geology, Austin, Texas.

METOICOCERAS WHITEI Hyatt

Metoicoceras whitei HYATT, *1903*, U. S. Geol. Survey Mon. 44, p. 122, pl. 13, figs. 3–5; pl. 14, figs. 1–10, 15.
Metoicoceras whitei MOREMAN, *1927*, Jour. Paleontology, vol. 1, no. 1, p. 94, pl. 15, fig. 1.
Metoicoceras whitei, ADKINS, *1928*, Texas Univ. Bull. no. 2838, p. 249, pl. 26, figs. 1. 2.

Metoicoceras whitei is one of the most abundant fossils in the Britton formation, having an extended vertical range and wide geographic distribution. The characters of this species are more variable than other species of *Metoicoceras*. Size variable, from two or three inches to 12 inches in diameter; compressed; umbilicus about one-tenth the entire diameter; umbilical tubercles absent; ribs weak on umbilical shoulders but stronger toward periphery; ventrolateral facets poorly to moderately well defined; suture with both saddles and lobes denticulate.

Horizon.—Middle and upper Britton formation.

Type locality.—Elm Fork of the Trinity River, Dallas County. Probably locality no. 16.

Characteristic specimen.—Moreman collection, Bureau of Economic Geology, Austin, Texas.

METOICOCERAS GIBBOSUM Hyatt

Metoicoceras gibbosum HYATT, *1901*, U. S. Geol. Survey Mon. 44, p. 121, pl. 15, figs. 5–8.

This species differs from *M. swallovi* in being more robust, has a smaller umbilicus and the umbilical tubercles are indistinct. Suture slightly more complex.

Horizon.—Britton formation.

Type locality.—Elm Fork of the Trinity River, Dallas County. Probably locality no. 16.

Locality.—No. 5.

Characteristic specimen.—Moreman collection, Bureau of Economic Geology, Austin, Texas.

METOICOCERAS ACCELERATUM Hyatt

Metoicoceras acceleratum HYATT, *1901*, U. S. Geol. Survey Mon. 34, pp. 127, 128, pl. 14, figs. 11–14.

This species is characterized by its small size and small umbilicus. It is a rare form and is not very well known.

Horizon.—Middle Britton formation.

Type locality.—Elm Fork of the Trinity River, Dallas County. Probably locality no. 16.

Locality.—No. 5.

Characteristic specimen.—Moreman collection, Bureau of Economic Geology, Austin, Texas.

METOICOCERAS IRWINI Moreman

Metoicoceras irwini MOREMAN, *1927*, Jour. Paleontology, vol. 1, no. 1, pp. 92–93, pl. 13, figs. 3, 4.

This species is characterized by being more compressed than other species of this genus; has a wide umbilicus, no umbilical tubercles and the ribs are more numerous and less prominent. It is closely related to *Metoicoceras pontieri* Leriche. In regard to the compressed whorl and low inconspicuous ribs, a more detailed comparison is impossible since the holotype is poorly preserved.

Horizon.—Britton formation.

Type locality.—No. 11.

Holotype.—Moreman collection, Bureau of Economic Geology, Austin, Texas.

METOICOCERAS KANABENSE Hyatt

Metoicoceras kanabense HYATT, *1903*, U. S. Geol. Survey Mon. 44, pl. 15, figs. 9–11.

This species has numerous low ribs, outer row of ventrolateral tubercles less prominent than inner row; umbilicus small; umbilical tubercles absent; greatest convexity between umbilicus and venter; suture more complex than other species, being minutely denticulated.

The holotype of this species is small but the general features of the Eagle Ford specimen are so similar that it seems impractical to make it a new species.

Horizon.—Britton formation.

Locality.—No. 6.

Characteristic specimen.—Moreman collection, Bureau of Economic Geology, Austin, Texas.

METOICOCERAS ORNATUM, n. sp.

Plate 32, figure 4; text figure 2c

Metoicoceras swallovi (Shumard), MOREMAN, *1927*, Jour. Paleontology, vol. 1, no. 1, p. 95, pl. 15, fig. 3.

This species is based on two specimens preserved as casts, the one here figured being designated as the holotype. The specimen figured in 1927 and erroneously called *M. swallovi* is poorly preserved but shows some features better than the holotype.

Medium size; whorl elevated and compressed; moderately involute; umbilicus rather broad, measuring slightly less than one-fourth the diameter of the specimen.

Venter slightly concave with prominent ventrolateral facets; last whorl bears 21 rather prominent ribs, which extend across the venter, alternating a long and a short with a long and two short ribs, the short ribs extending only halfway from the venter to the dorsum while the long ribs extend all the way and are expanded into transversely elongated tubercles on the umbilical shoulder; ribs on penultimate whorl are alternately short and long. In the paratype the ribs become very prominent on the last third of the living chamber, and arch slightly for-

ward as they cross the venter. The paratype is slightly larger, being about 128 mm. in diameter.

Suture characterized by a low siphonal lobe with few lobules, first lateral lobe high, bifid, with numerous lobules, remaining four lateral lobes become increasingly lower and less intricate; first saddle moderately denticulate, while remainder are simple or with one or two obscure indentations.

Measurements: Diameter, 115 mm.; greater radius, 61 mm.; lesser radius, 39.5 mm.; height of last whorl, 49 mm.; height of penultimate whorl, 27 mm.; height of last whorl above venter, 41 mm.; involution, 13 mm.; thickness of last whorl, 41.5 mm.; thickness of penultimate whorl, 20 mm.; width of umbilicus, 20.3 mm.; suture taken at diameter of, 64 mm.

Remarks.—This species resembles *M. swallovi* (Shumard) in having prominent transversely elongate tubercles on the umbilical shoulders, and simple saddles in the suture. It differs from *M. swallovi* in having more prominent ribs and tubercles especially on the living chamber. In *M. swallovi* the last few ribs are low and tend to curve backward near the umbilical shoulder and do not develop such prominent transversely elongate tubercles.

Horizon.—About the middle of the Britton formation.

Locality.—No. 6.

Holotype and Paratype.—Moreman collection, Bureau of Economic Geology, Austin, Texas.

Family Prionotropidae Zittel
Genus Barroisiceras Grossouvre

Two species of this genus have been found by the writer in the Britton formation associated with characteristic forms of the *Metoicoceras whitei* zone. It is noteworthy that in North America and Europe *Barroisiceras* has previously been cited only from strata of Coniacian age. A study of this genus was recently made by Reeside (1932) in which he described six new species.

The sutures and sculpture of the Britton species of *Barroisiceras* are somewhat simpler than those of the Coniacian species, and it is possible that they are the ancestors of those from the Coniacian.

Barroisiceras trinodosum Moreman, n. sp.

Plate 33, figures 1, 2; text figure 2a

This species is based on a single mold of the living chamber which shows the outline of the last suture.

Medium size; compressed; elevated; only slightly involute; suboval in cross-section; flanks somewhat flattened; venter triangular; umbilicus broad.

There are 10 nearly straight ribs which are rather obscure near the umbilicus, but become stronger as they cross the venter, each bearing a slightly longitudinally elongated ventral tubercle, which gives the venter a carinate appearance, and a rounded somewhat lower ventrolateral tubercle, thus making the venter triangular; ribs are alternately long and short except in one place, where two short ribs occur together; umbilical shoulders practically smooth.

Suture of three lateral lobes and saddles, simple in outline and moderately denticulate; first two saddles broad, third very much smaller both in length and breadth; lobes about one-half the size of the saddles.

Measurements: Height of whorl, 58.5 mm.; thickness of anterior end of whorl, 35 mm.; thickness of posterior end of whorl, 25 mm.; involution, 8 mm.; height of last whorl above venter, 53 mm.

Remarks.—This species differs from other species of *Barroisiceras* by having a much simpler suture and in not developing umbilical tubercles. *B. brancoi* var. *armatum* Solger does not develop umbilical tubercles but in later stages marginal spines replace the marginal tubercles and the venter is rounded.

Horizon.—Middle of Britton formation.

Locality.—No. 9.

Holotype.—Moreman collection, Bureau of Economic Geology, Austin, Texas.

Barroisiceras brittonense Moreman, n. sp.

Plate 33, figure 3; text figure 2b

This species is based upon a cast of the living chamber which has a portion of the last suture preserved.

Medium-sized; slightly compressed; elevated; moderately involute; suboval in cross-section; venter triangular; flanks somewhat flattened; umbilicus broad.

Ten straight prominent ribs cross the venter, each bearing a median and a ventrolateral tubercle; on the flanks the ribs are alternately long and short, the short ones becoming obscure about the middle of the flanks while the long ones extend fully developed to the umbilical shoulder.

Suture poorly preserved but appears to consist of three lobes and three saddles, simple in outline and moderately denticulate.

Measurements: Height of whorl, 58 mm.; thickness of anterior end of whorl, 40 mm.; thickness of posterior end of whorl, 30 mm.; height of whorl above venter, 45 mm.; involution, 15 mm.

Remarks.—This species differs from *B. trinodosum* Moreman in having stronger and regularly alternating long and short ribs; whorls less elevated and more gibbous; and umbilicus broader.

Horizon.—Middle part of the Britton formation.

Locality.—No. 5.

Holotype.—Moreman collection, Bureau of Economic Geology, Austin, Texas.

Genus NEOCARDIOCERAS Spath

NEOCARDIOCERAS SEPTEMSERIATUM (Cragin)

Plate 33, figures 11, 12; text figure 2f

Scaphites septem-seriatus CRAGIN, *1893*, Texas Geol. Survey Ann. Rept. no. 4, p. 240.
Acanthoceras kanabense STANTON, *1893*, U. S. Geol. Survey Bull. 106, p. 181, pl. 36, figures 6–8.
Acanthoceras kanabense, MOREMAN, *1927*, Jour. Paleontology, vol. I, no. 1, p. 95, pl. 13, fig. 5.
Kanabiceras kanabense REESIDE and WEYMOUTH, *1931*, U. S. Nat. Mus. Proc., vol. 78, Art. 17, pl. 11.
Neocardioceras septem-seriatus ADKINS, *1931*, Texas Univ. Bull. No. 3101, p. 60–63.

In his article on "Some Upper Cretaceous ammonites in western Texas," Adkins (1931) gave a very full description of this species and included a discussion of the priority of the name.

Recently Reeside made a comparison of all specimens of *Acanthoceras kanabense* collected from the western interior with material sent him from Texas by the writer. He believes that all the American material constitutes a single species and that *Neocardioceras* will have to be accepted as the generic name.[1]

[1] Unpublished data.

A well-preserved specimen of this species is here figured.

Type locality.—Kennan's Crossing of Trinity River, Dallas County.

Locality.—No. 6.

Holotype.—Now in Bureau of Economic Geology, Austin, Texas.

Figured specimen.—Moreman collection, Bureau of Economic Geology, Austin, Texas.

Genus PRIONOTROPIS Meek

PRIONOTROPIS GRAYSONENSIS (Shumard)

Ammonites graysonensis SHUMARD, *1860*, Acad. Sci. St. Louis Trans., vol. 1, p. 586.
Ammonites graysonensis, WHITE, *1883*, U. S. Geog. and Geol. Surv. Terr. (Hayden) 12th Ann. Rept., pt. 1, p. 39, pl. 28, figs. 9 a, b.
Prionotropis aff. *woolgari* MOREMAN, *1927*, Jour. Paleontology, vol. I, no. 1, pl. 13, fig. 2.

The specimen which was figured by the writer in 1927 agrees with Shumard's description very closely and resembles the figure as published by White.

Prionotropis graysonensis differs from *Prionotropis* aff. *woolgari* as figured by Meek (1876) from the western interior, in that the whorls are usually shorter in proportion to the width, and the keel is not so distinctly serrate.

It is the most common species of *Prionotropis* found in the Eagle Ford group.

Horizon.—Lower Arcadia Park formation.

Locality.—No. 17.

Characteristic specimen.—Moreman collection, Bureau of Economic Geology, Austin, Texas.

PRIONOTROPIS HYATTI Stanton

Prionotropis hyatti STANTON, *1893*, U. S. Geol. Survey Bull. 106, p. 176, pl. 42, figs. 5–8.

Several specimens in the collections of both W. S. Adkins and the writer agree almost exactly with the description and figures given for the type material.

In the young stages the ribs are numerous and irregularly developed, some are more prominent than others and extend to the umbilicus while the others are lower and shorter. One specimen which is about 2 inches in diameter has ribs more widely spaced, umbilical tubercles on about every third or fourth rib, and the ventrolateral tubercle is rather prominent and extended

laterally, giving the venter a flat appearance. The keel is irregularly serrate.

Horizon.—Arcadia Park formation.

Localities.—Nos. 17 and 18.

PRIONOTROPIS aff. WOOLGARI Meek (not Mantell)

Prionotropis woolgari MEEK, *1876*, U. S. Geol. Survey Terr. 9th Ann. Rept., pl. 7, figs. 1 a-h and 3, pl. 6, fig. 2.

Numerous small specimens collected from the Arcadia Park formation are inseparable from the early stages of *Prionotropis woolgari* as described from the Benton of the western interior, first by Meek (1876) and later by Stanton. Since the adult specimens are rarely well preserved it is difficult to make an accurate comparison with the typical *P. woolgari* described by Mantell from the Upper Turonian of Europe.

Horizon.—Arcadia Park formation.

Locality.—No. 18.

Characteristic specimen.—Moreman collection, Bureau of Economic Geology, Austin, Texas.

Genus PRIONOCYCLUS Meek

PRIONOCYCLUS MEEKIANUS (Shumard)

Ammonites meekianus SHUMARD, *1860*, Acad. Sci. St. Louis Trans. vol. 1, p. 592.

Specimens collected from the Arcadia Park formation have features which agree essentially with the original description of this species given by Shumard. They represent both young and adult stages and are here being presented as neotypes.

Cross-section of whorl subquadrate, sides flat; dorsum flat or very gently convex, marked by a continuous well-defined keel at all stages. In the young stage each rib has two ventrolateral tubercles, and on the last whorl of a specimen less than an inch in diameter the last few ribs have bullate umbilical tubercles. In the older stages there is a single prominent ventrolateral tubercle on every third rib giving the venter a flat appearance. On a fragment of a large specimen which probably measured 12 to 15 inches in diameter the ventrolateral tubercle is very prominent and extended laterally; venter flat with a deep depression on each side of the keel.

Horizon.—Arcadia Park formation.

Locality.—No. 17.

Neotypes.—Bureau of Economic Geology, Austin, Texas. Moreman collection.

PRIONOCYCLUS NOVIMEXICANUS (Marcou)

Ammonites novi-mexicani MARCOU, *1858*, Geol. of North America (etc.), p. 35; pl. 5, figs. 1a–1b, Zurich.

A fragment of this species was collected from the Arcadia Park formation near Austin, Texas. The whorl is compressed; surface marked by numerous ribs which arch anteriorly as they go on to the flattened venter; relatively deep furrows are excavated on each side of the continuous keel.

Measurements: Height of whorl, 38 mm.; width of whorl, 26 mm.

Horizon.—Arcadia Park formation.

Locality.—Near Austin, Texas. The writer was unable to obtain information as to exact location.

Holotype.—Brit. Mus. (Nat. Hist.), South Kensington, B. M. No. 12666. Plaster replicas in Bureau of Economic Geology, Austin, Texas.

Characteristic specimen.—Adkins collection, Bureau of Economic Geology, Austin, Texas.

Family COSMOCERATIDAE
Subfamily SCAPHITINAE
Genus WORTHOCERAS Adkins

WORTHOCERAS VERMICULUM (Shumard)

Plate 34, figures 12, 13; text figure 2p

Scaphites vermiculus SHUMARD, *1860*, Acad. Sci. St. Louis Trans. p. 594.

Worthoceras vermiculus ADKINS, *1928*, Texas Univ. Bull. 2838, p. 220.

This species was first described without an accompaning figure, but later White (1883) published a drawing made by Shumard, presumably of the holotype. Shumard did not describe the suture of this species and consequently its exact relationship is unknown. Meek (1876) referred *Scaphites vermiculus* to *Macroscaphites* on the basis of its shape. Adkins (1928) referred it tentatively to a new genus, *Worthoceras*, which he erected for forms that occur in the upper Duck Creek and Paw Paw formations. Recently the writer collected a specimen from the Britton formation which is being proposed as a neotype to take the place of the holotype which is apparently lost.

Horizon.—Britton formation.
Locality.—No. 5.
Neotype.—Bureau of Economic Geology, Austin, Texas. Moreman collection.

WORTHOCERAS GIBBOSUM, n. sp.
Plate 34, figures 7, 8; text figure 2q

This species is based on a cast which in places retains the original shell.

Small size; whorl depressed; venter rounded; flanks convex; initial portion a planospiral coil, followed by a straight portion, which connects to a shorter limb subparallel to the first but not touching it, and continuing to within 1 mm. of the coiled portion; body whorl gradually increasing in width from the initial portion to the aperture; volutions of the coil partially embracing, leaving a deep umbilicus in which three or four coils are visible; umbilicus comparatively broad, being one-third of the diameter of the coiled portion.

Surface marked by very obscure ribs or striae which are devoid of tubercles.

The suture of this species is slightly more complex than the genotype *W. platydorsum* (Scott) but resembles that of *W. worthense* Adkins very closely. Consists of four lobes and four saddles. There is a quadrate siphonal lobe divided by a simple saddle, the lobules being entire; first lateral saddle broad and divided by secondary indentations, having one lobule which makes it bifid; the second saddle is indented on the side toward the siphon, but smooth on the other, the third and fourth saddles are without indentations; the first lateral saddle is bifid, while the third and fourth are smooth.

Measurements: Diameter of coiled portion, 10 mm.; length of straight portion along the dorsum, 7 mm.; height of deflected portion, 15 mm.; length of entire specimen, 18 mm.; height of apertural face, 6 mm.; width of apertural face, 7 mm.; umbilicus, 3 mm.

Remarks.—This species is thicker in proportion to its size than any other species of *Worthoceras* yet described, the straight limb is shorter and the aperture extends back closer to the coiled portion. The suture has the same general form as *W. platydorsum* but is marked by more indentations in the first and second saddles, while the third and fourth are smooth.

Horizon.—Middle part of the Britton formation.
Locality.—No. 5.
Holotype.—Bureau of Economic Geology, Austin, Texas. Moreman collection.

Genus SCAPHITES Parkinson
SCAPHITES BRITTONENSIS Moreman, n. sp.
Plate 34, figures 1, 2; text figure 2r

This species is based on a cast which still retains part of the original shell.

Small size; initial portion a planospiral coil, followed by a straight portion, which connects to a shorter limb subparallel to the first but not touching it, and continuing to within 2 mm. of the coiled portion; body whorl gradually increasing in width up to the beginning of the straight limb then continuing at the same width to the aperture which flares slightly, forming a slight ventral lip; volutions few; deeply involute, overlapping so that the umbilicus is small and shallow.

Ribs are very fine and numerous on the venter, two of these ribs unite at the ventrolateral margin, to form a small tubercle, and these paired ribs alternate with one or sometimes two ribs, which become obscure at the ventrolateral margin; from these tubercles slightly coarser ribs extend across the flanks; on the coiled portion these ribs extend to the umbilical shoulder, while on the deflected portion the ribs become obscure just short of the umbilical shoulder.

Suture a broad siphonal lobe divided by relatively simple saddle, first lateral lobe small and trilobate, second lateral lobe larger and bifid, third lateral lobe trilobate, fourth simple; first saddle bifid, second, third, and fourth bifid and moderately denticulate.

Measurements: Length, 19 mm.; diameter of coil, 11 mm.; height, 17 mm.; length of straight portion along dorsum, 5 mm.; height of apertural face, 7 mm.; width of apertural face, 9 mm.; width of penultimate whorl, 7 mm.

Remarks.—*Scaphites brittonensis* resembles *Scaphites aequalis* Sowerby in general appearance but the latter species has a wide umbilicus, the early whorls are narrower and the increase in thickness to the deflected portion is proportionately greater. *Scaphites brittonensis* has stronger and more regularly

spaced ribs on the flanks and the dorsal margin of the deflected portion to the recurved aperture. The suture line of *S. aequalis* is slightly more denticulate. It is similar to *Scaphites geinitzi* (d'Orbigny) in the nature of the sculpture and suture, but the whorl of the latter species is relatively much narrower.

Horizon.—Britton formation.

Locality.—No. 5.

Holotype.—Bureau of Economic Geology, Austin, Texas. Moreman collection.

SCAPHITES MINUTUS, Moreman, n. sp.
Plate 34, figures 9, 10; text figure 2s

This species is based on a single well preserved cast.

Small size; initial portion a planospiral coil; deflected portion extends out straight for a short distance then turns back in a rather broad curve so that the aperture is situated somewhat above but within 2 mm. of the coiled portion; the ventral margin of the aperture bears a distinct lip, which rises about 1 mm. above the venter; body whorls gradually increase in thickness up to the deflected portion then continues uniformly; whorls few, moderately involute; umbilicus relatively broad and deep, revealing two or three earlier volutions.

Surface marked by numerous low ribs especially on the coiled portion; these extend from the umbilical margin entirely across the venter and alternate ones bear a slightly elongated tubercle on the ventrolateral margin; ribs on deflected portion are more obscure, particularly where the original shell has been removed; no evidence of tubercles on the deflected portion since the shell has been removed except across the venter, but it is evident that they must have been obscure even on the shell.

Measurements: Length, 11.5 mm.; height, 10.5 mm.; width of aperture, 5 mm.; height of aperture, 4 mm.; width of penultimate whorl, 3 mm.; umbilicus, 2mm.

Remarks.—This species is characterized by having a relatively wide umbilicus; a rather long deflected portion which rises higher above the coiled portion than in most species; and rather obscure ribs on the deflected portion.

Horizon.—Britton formation.

Locality.—No. 5.

Holotype.—Bureau of Economic Geology, Austin, Texas. Moreman collection.

SCAPHITES PYGMAEUS Morrow
Plate 34, figures 5, 6

Scaphites pygmaeus MORROW, *1935*, Jour. Paleontology, vol. 9, p. 465, pl. 50, figs. 2a–e, 3.

The size and sculpture of the specimen here figured agrees very closely to *Scaphites pygmaeus* Morrow which was described from the Carlile formation of Kansas.

Horizon.—Arcadia Park formation.

Locality.—No. 19.

Figured specimen.—Bureau of Economic Geology, Austin, Texas.

SCAPHITES ARCADIENSIS, n. sp.
Plate 34, figure 3

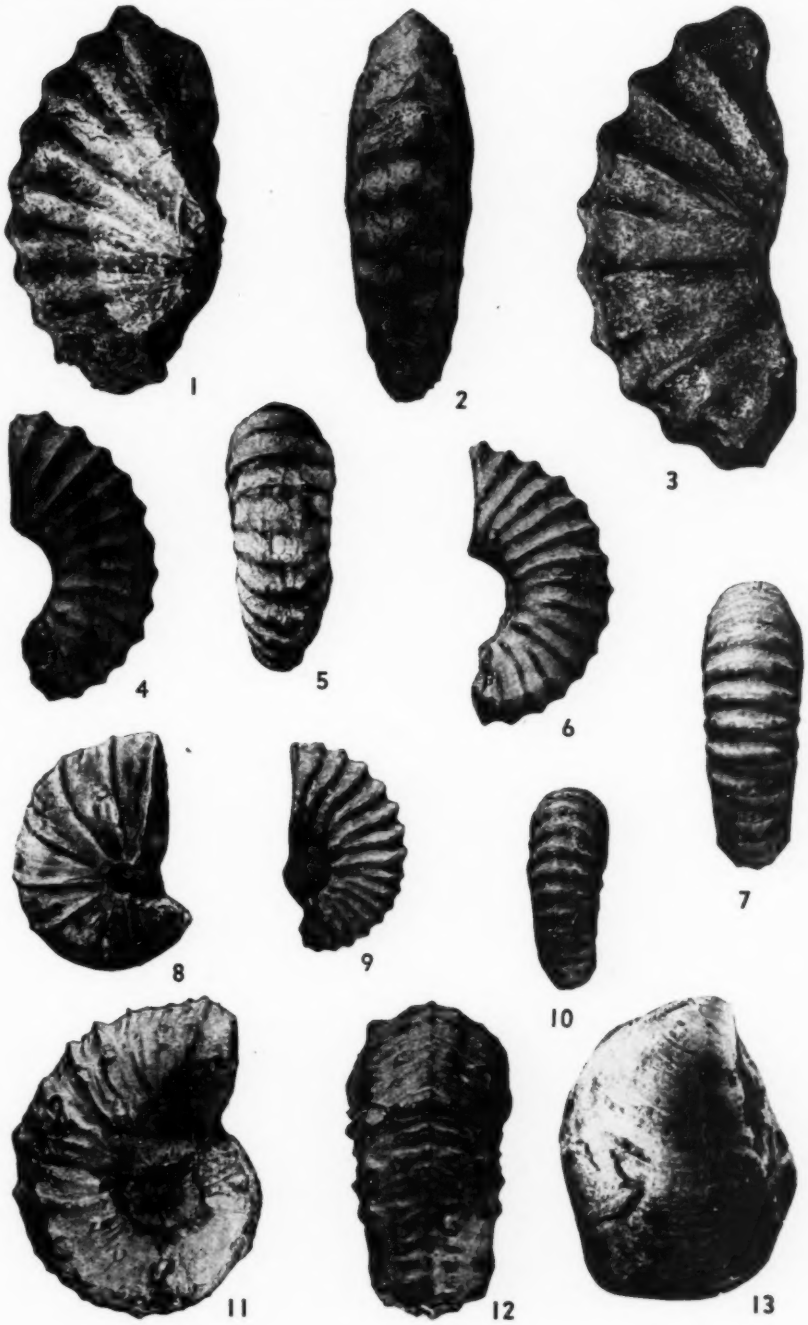
This species is based upon a cast which still retains a portion of the original shell.

Small size; initial portion a planospiral coil; deflected portion extends out straight for a short distance, then turns back in a rather broad curve, so that the aperture is situated somewhat above but within 2 mm. of the coiled portion; body whorl gradually increasing in size; volutions few; deeply involute; umbilicus very small and shallow.

On the coiled portion the ribs are rather fine and numerous, passing entirely across the venter; on the earliest portion of the shell the ribs anastomose in pairs about the middle of the flanks and pass as one more prominent rib to the unbilical shoulder; on the

EXPLANATION OF PLATE 33

FIGS. *1, 2—Barroisiceras trinodosum*, holotype, n. sp., ×½. (p. 212)
3—Barroisiceras brittonense, holotype, n. sp., ×½. (p. 212)
4, 5—Eucalycoceras dentonense, holotype, n. sp., ×½. (p. 205)
6, 7—Eucalycoceras lewisvillense, holotype, n. sp., ×½. (p. 206)
8—Tragodesmoceras scotti, holotype, n. sp., ×½. (p. 208)
9, 10—Eucalyoceras indianense, holotype, n. sp., ×½. (p. 206)
11, 12—Neocardioceras septemseriatum (Cragin), hypotype, ×½. (p. 213)
13—Inoceramus sp. 2, ×½. (p. 200)



Moreman, Upper Cretaceous Fossils

Moreman, Upper Cretaceous Fossils

later portion of the coil every third rib plays out about the middle of the flanks, and the two ribs in between anastomose and pass as a single, more prominent rib to the umbilical shoulder; at each point of anastomosing a transversely elongated tubercle is formed. The ribs on the remainder of the shell are fewer and very much coarser; four very prominent tubercles are formed on the flanks of this portion by the anastomosing of three or four of the coarser ribs; these ribs disappear at the tubercles and do not pass to the dorsum.

Siphonal and first lateral lobes are bifid and simply denticulated, second lateral lobe is very small and simple. First lateral saddle is broad and bifid; second and third are much smaller and simply denticulated.

Measurements: Length, 26 mm. diameter of coil, 14 mm.; height, 21 mm.; length of straight portion along dorsum 9 mm.; height of apertural face, 7 mm.; width of apertural face, 12 mm.; width of penultimate whorl, 5 mm.

Remarks.—The coiled portion of this species is similar to *Scaphites pygmaeus* Morrow, but the deflected portion differs in that the cross-section is only about half as high, the ribs are coarser and there are fewer but more prominent tubercles on the flanks.

Horizon.—Arcadia Park formation.

Locality.—No. 17.

Holotype.—Moreman collection, Bureau of Economic Geology, Austin, Texas.

Family ENGONOCERATIDAE Hyatt
Genus PROTENGONOCERAS Hyatt
PROTENGONOCERAS PLANUM Hyatt

Protengonoceras planum HYATT, *1903*, U. S. Geol. Survey Mon. 44, pp. 156–157, pl. 27, figs. 6–9. ADKINS, *1928*, Texas Univ. Bull. 2838, p. 261.

This species, based on a small fragment from an unknown locality is thought to have come from the Britton formation because the matrix is characteristic of that part of the Eagle Ford at Horton's Mill, Dallas County, Texas.

Whorls flat with smooth flanks; venter smooth, very narrow and concave; suture with 10 saddles and lobes, the latter being club shaped, the second to the fifth faintly trifid.

Horizon.—Britton formation (?).

Type locality.—Probably Dallas County.

Genus EPENGONOCERAS Spath
EPENGONOCERAS DUMBLI (Cragin)

Sphenodiscus dumbli CRAGIN, *1893*, Texas Geol. Survey, Ann. Rept. no. 4, p. 243, pl. 44, fig. 6.
Metengonoceras dumbli HYATT, *1903*, U. S. Geol. Survey, Mon. 44, p. 185, pl. 27, figs. 3–14.
Engonoceras dumbli LASSWITZ, *1904*, Geol. u. Palaeont. Abh., IV, Heft IV.
Epengonoceras dumbli SPATH, *1924*, Amm. Gault Folkstone, p. 508.
Epengonoceras dumbli, ADKINS, *1928*, Texas Univ. Bull. 2838, p. 264.

Only the suture of this species was figured by Cragin, while Hyatt figured a specimen from the type locality.

The following is the original description by Cragin:

Shell of medium size, strongly compressed, lenticular, consisting of about four volutions, of which the outer completely embraces the inner; periphery cuneate, very sharp in the young, becoming obtuse along the body-chamber of adult specimens; sides evenly flattish-convex, or having suggestions of low and broad undulations, marked with numerous fine growth-lines whose radial course is interrupted about mid-way between periphery and umbilicus by a gently, anteriorly convex flexure or embayment; umbilicus narrow, of moderate depth, its shoulder rounded; body-chamber comprising half a volution; aperture high and narrow; sutural lines sometimes crowded throughout their length, but oftener separate on the ventral half of the whorl-flank, consisting of numerous small leaves and saddles; the saddles 14 or 15 in number on either side, much broader than the leaves, consisting for the most part of simple, laterally inflated,

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EXPLANATION OF PLATE 34

FIGS. *1, 2—Scaphites brittonensis*, holotype, n. sp., ×2. (p. 215)
3—Scaphites arcadiaensis, holotype, n. sp., ×1. (p. 216)
4—Allocrioceras dentonense, holotype, n. sp., ×1. (p. 209)
5, 6—Scaphites pygmaeus Morrow, hypotype, ×1. (p. 216)
7, 8—Worthoceras gibbosum, holotype, n. sp., ×2. (p. 215)
9, 10—Scaphites minutus, holotype, n. sp., ×2. (p. 216)
11—Inoceramus fragilis Hall and Meek, hypotype, ×1. (p. 199)
12, 13—Worthoceras vermiculum (Shumard), neotype, ×2. (p. 214)

terminally rounded, or sometimes truncated cells which increase regularly in size from the first to the sixth or seventh, thence diminishing somewhat irregularly to the umbilicus, the first eight saddles entire, the ninth and other inner saddles variably cleft, notched, or simple, those near the umbilicus becoming subquadrate by mutual limitation, and at the shoulder of the umbilicus being exceptionally broad; siphonal leaf consisting of two small and short, widely divergent digits, arising from a narrow stripe, and forming a character intermediate between the letters T and Y; lateral leaves usually with narrow stripes divided above into two small, usually rounded (somewhat pointed), terminal lobes by an emargination or cleft, and, in the larger leaves, with one or two additional lower lobes on either side; the leaf lobes usually short, sometimes long and digitiform, rounded or pointed, rarely truncate or terminally bidentate.

Remarks.—Epengonoceras dumbli occurs in its characteristic development in the Tarrant formation of north Texas, but reference has been made to its occurrence in the Britton formation of Dallas County. A specimen in the Bureau of Economic Geology at Austin, Texas collected by W. F. Cummins on Hackberry Creek in Dallas County and labeled *Sphenodiscus dumbli* is poorly preserved but resembles *Epengonoceras acutum* Hyatt more closely than *E. dumbli.* It is more than likely that the specimen recorded from Kennan's Crossing on the Trinity River in Dallas County was similarly confused with *E. acutum.*

Horizon.—Tarrant formation.

Type locality.—4 miles east of Whitesboro, Texas and 0.25 mile south of the Whitesboro-Sherman road.

Locality.—No. 1.

Holotype.—Bureau of Economic Geology, Austin, Texas.

Characteristic specimen.—Moreman collection, Bureau of Economic Geology, Austin, Texas.

EPENGONOCERAS ACUTUM (Hyatt)

Metengonoceras acutum HYATT, *1903*, U. S. Geol. Survey, Mon. 44, p. 184, pl. 26, fig. 8; pl. 27, figs. 1, 2.

Epengonoceras acutum ADKINS, *1928*, Texas Univ. Bull. 2838, p. 264.

A nearly complete cast of this species was collected near the type locality.

Form much compressed and involute; flanks with obscure foldlike ribs; venter acute, concave on early whorls but sharp or very slightly rounded on living chamber; suture with lobes narrow at the base and bifid, eighth and ninth very faintly trifid.

The larger size of the lobes and saddles and the more acute venter in the early stages distinguish this species from *Epengonoceras dumbli.*

Horizon.—Britton formation.

Type locality.—Elm Fork and West Fork (Horton's Mill) of the Trinity River, Dallas County.

Locality of hypotype.—No. 15, Moreman collection, Bureau of Economic Geology, Austin, Texas.

Family COILOPOCERATIDAE
Genus COILOPOCERAS Hyatt
COILOPOCERAS COLLETI Hyatt

Coilopoceras colleti HYATT, *1903*, U. S. Geol. Survey Mon. 44, p. 91, pl. 10, figs. 5–21; pl. 11, fig. 1.

A specimen collected form the Arcadia Park formation has essentially the features of this species described from the Colorado group, near Carthage, New Mexico. It is characterized by having relatively stout whorls, open umbilicus, and fold-like ribs which are alternately long and short, the long ones reaching the umbilicus. Diameter of specimen from the Arcadia Park formation is 50 mm.

Horizon.—Condensed Arcadia Park formation.

Locality.—Watter's Park.

Characteristic specimen.—Adkins collection, Bureau of Economic Geology, Austin, Texas.

COILOPOCERAS aff. EAGLEFORDENSE Adkins

Coilopoceras eaglefordense ADKINS, *1931*, Texas Univ. Bull. 3101, p. 46, pl. 4, figs. 4, 8; pl. 5, fig. 1.

Numerous fragments which resemble this species have been collected from the Arcadia Park formation. It is characterized by having elevated whorls which are thickest about 0.4 of the way from the umbilicus to the venter; dorsal portion of flank convex, remainder almost flat; umbilical wall practically vertical; surface devoid of ribs and tubercles.

Horizon.—Arcadia Park formation.

Locality.—No. 19.

Hypotype.—Adkins collection, Bureau of Economic Geology, Austin, Texas.

Family PLACENTICERATIDAE Hyatt
Genus PROPLACENTICERAS Spath
PROPLACENTICERAS CUMMINSI (Cragin)

Placenticeras syrtalis Morton, var *cumminsi* CRAGIN, *1893*, p. 237.
Placenticeras cumminsi ADKINS, *1928*, Texas Univ. Bull. 2838, p. 253.

The specimen upon which this species was based is very fragmentary, consisting of only part of the living chamber and the last few septae. It is characterized by having stout whorls, relatively broad venter and both umbilical and ventral tubercles.

Horizon.—Britton formation.

Type locality.—Hackberry Creek, Dallas County.

Holotype.—Bureau of Economic Geology, Austin, Texas.

PROPLACENTICERAS STANTONI var. BOLLI (Hyatt)

Placenticeras stantoni var. *bolli* HYATT *1903*, U. S. Geol. Survey Mon. 44, p. 214, pl. 40, figs. 3–7; pl. 41; pl. 42; pl. 43, figs. 1–2.

This variety is very closely related to *Proplacenticeras cumminsi*, especially in regard to the tubercles on the venter and umbilicus. It is very likely that both the varieties later described by Hyatt from the Eagle Ford were included in the specimens used by Cragin in describing *P. cumminsi*. The specimens used by both writers came from the same area in Dallas County.

Horizon.—Britton formation.

Type locality.—Elm Fork and West Fork of the Trinity River, Dallas County and Tarrant County, Texas.

Locality of hypotype.—No. 5, Bureau of Economic Geology, Austin, Texas. Moreman collection.

PROPLACENTICERAS PSEUDOPLACENTA var. OCCIDENTALE (Hyatt)

Placenticeras pseudoplacenta var. *occidentale* HYATT, *1903*, U. S. Geol. Survey Mon. 44, p. 217, pl. 45, figs. 1–2.

This variety is characterized by having a relatively broad venter; umbilical tubercles in adult stage; suture more immature than in related forms.

Several specimens collected in Ellis County south of Britton have features essentially like those described by Hyatt.

Horizon.—Britton formation.

Type locality.—Elm Fork, Dallas County, Texas; upper Missouri, Bad Lands, South Dakota.

Hypotype.—Moreman collection, Bureau of Economic Geology, Austin, Texas.

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PERMIAN AMMONOIDS FROM WESTERN AUSTRALIA

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ABSTRACT.—Late Palaeozoic ammonoids occur in Western Australia in three districts: Irwin River (*Metalegoceras jacksoni*), North-West District (*Paragastrioceras wandageense*, *Pseudogastrioceras goochi*, *Propinacoceras paucilobatum*), and West Kimberley District (*Metalegoceras clarkei*, *M. striatum*, *Thalassoceras wadei*). The age relationships of these faunas are discussed. The youngest (with *Paragastrioceras* etc.) is Artinskian, the oldest (*Metal. jacksoni*) hardly younger than Sakmarian. A number of new species are described.

ONE of the greatest difficulties involved in the correlation of the late Palaeozoic deposits of Australia with those of other parts of the world is the scarcity of ammonoids in this continent. For many years "*Gastrioceras*" *jacksoni* of the Irwin River District of Western Australia, first described by Etheridge in 1907 and now recognized as a species of the genus *Metalegoceras*, was the only late Palaeozoic ammonoid known from the Australian continent. With one exception no ammonoids have as yet been found in the "Permo-Carboniferous" or "Kamilaroi" of the eastern part of Australia, but two additional ammonoid localities have been discovered in recent years in different parts of Western Australia.

Late Palaeozoic or "Permo-Carboniferous" deposits in Western Australia are developed in three main regions, commonly referred to as the Irwin River, North-West, and West Kimberley Districts or Divisions (see map, fig. 1). Lithology, fauna, and succession of strata in the two last-mentioned regions are somewhat similar, whereas the Irwin River District in many respects shows a different development. A review and correlation of these sequences has been given in more detail elsewhere (Teichert, 1941).

The first find of ammonoids outside the Irwin River District was made by Dr. Arthur Wade in the Kimberley District, and the species from this collection were described by A. K. Miller in 1936 as *Metalegoceras clarkei* and *Thalassoceras wadei*. This little fauna came from the top part of the Nura Nura limestone which I consider to be the equivalent of the Fossil Cliff and Callytharra limestones of the Irwin River and North-West Districts respectively. On a recent visit to the locality from which Dr. Wade's specimens were obtained, I collected additional specimens of the two species mentioned above, some of which enable me to make slight additions to the knowledge of *Thalassoceras wadei*. I also found a specimen which represents a new species of *Metalegoceras*, *M. striatum*.

FIG. 1.—Map of Western Australia. The crosses indicate the occurrences of Permian ammonoid faunas.

A third occurrence of ammonoids was

quite recently discovered in the North-West District by Mr. H. Coley, an enthusiastic amateur collector in this sparsely populated country. Further ammonoid localities and horizons in the same general area were found by me in 1939 and 1940. The ammonoids occur here at a stratigraphic level considerably above the ammonoid bearing horizons of the Irwin River as well as of the Kimberley District. They are found throughout a thickness of about 1500 feet in the middle and higher parts of the Wandagee series. The vertical distribution of the species appears in figure 2. It should be noted that *Paragastrioceras wandageense* and some specimens of *Propinacoceras australe* have been found at approximately the same stratigraphic level as *Helicoprion davisii* (Teichert, 1940).

There are marked differences in the composition of the ammonoid faunas from the three parts of Western Australia mentioned above. This, however, is not surprising in view of the fact that the three faunas are of slightly different age and in view of the considerable geographical distances involved.

The oldest fauna is that with *Metalegoceras jacksoni* from the Irwin River. No other species occurs here. According to unpublished data in the Department of Geology of the University of Western Australia, collected by Professor E. de C. Clarke and students (K. L. Prendergast and N. E. Luck), *M. jacksoni* occurs in places at three distinct horizons between 800 and 1500 feet above the basal tillites. Miller has observed (1932, p. 438) that the sutures of this species "are distinctly more primitive than those of any species of *Metalegoceras* of which the sutures are fully known." Since then, Ruzhencev (1938, p. 278) has described a still more primitive species, *Metalegoceras distale*, from the upper Kurmaia limestone of the Sakmarian in which the second external, the umbilical, and the second internal lobes are still less developed than in *M. jacksoni* (see fig. 6). The Kurmaia limestone forms the middle part of the Sakmarian sequence in the South Urals and an approximately similar age may be assumed for the *Metalegoceras beds* of the Irwin River. Also, the approximately contemporaneous *Metalegoceras colemanense* Plummer and Scott (1937) from the Wichita group of north-central Texas exhibits features as primitive as those of *M. jacksoni*. In any case, the fact that *M. jacksoni* has not yet reached the stage of the development of any known species of Artinskian age (compare also the Artinskian species described as *Dodecalegoceras* by Voinova in 1934) seems to suggest a pre-Artinskian age of the beds in which it occurs. This is also the opinion of Miller and Furnish who have recently stated (1940, p. 26) that they regard *M. jacksoni* as a presumably Lower Permian fossil.

Next in age is the Nura Nura limestone assemblage of the Kimberley District with *Metalegoceras clarkei*, *M. striatum*, and *Thalassoceras wadei*. Both species of *Metalegoceras* are decidedly more advanced than *M. jacksoni* (see fig. 6). Their sutures resemble those of typical Artinskian species. On general evidence the Nura Nura limestone is correlated by me with the Callytharra limestone of the North-West which is probably an equivalent of the Lower Productus limestone of the Salt Range of India and, therefore, of Artinskian age. If this correlation is correct the Nura Nura limestone should be referred to the base of the Artinskian.

The youngest fauna is that of the Wandagee series in the North-West District, where the following species occur: *Propinacoceras australe*, *Paragastrioceras wandageense*, and *Pseudogastrioceras goochi*, as well as another as yet unnamed species of *Pseudogastrioceras*. These species are distributed in a number of horizons throughout a thickness of about 1500 feet in the middle and upper parts of the Wandagee series and, at one horizon, where representatives of all three species have been found, they occur associated with the shark *Helicoprion davisii* which has been redescribed in a recent paper (Teichert, 1940). At this horizon a number of additional small ammonoids occur which, however, are too poorly preserved for even generic determination. The Artinskian age of this assemblage is beyond doubt. Whereas *Propinacoceras* and *Pseudogastrioceras* have a longer range throughout the Permian, typical *Paragastrioceras* seems to be restricted to beds of Artinskian age.

The stratigraphical relationships of the three Western Australian ammonoid faunas, as at present interpreted, are shown diagrammatically in figure. 2.

In view of the fact that the Permian ammonoid-bearing strata of Timor are geographically nearer to those of Western Australia than any other region with strata in a similar facies, attention should be drawn to the fact that the ammonoid faunas of these two regions seem to have little in common. *Pseudogastrioceras* and *Paragastrioceras* are unknown from Timor, and the Timor species

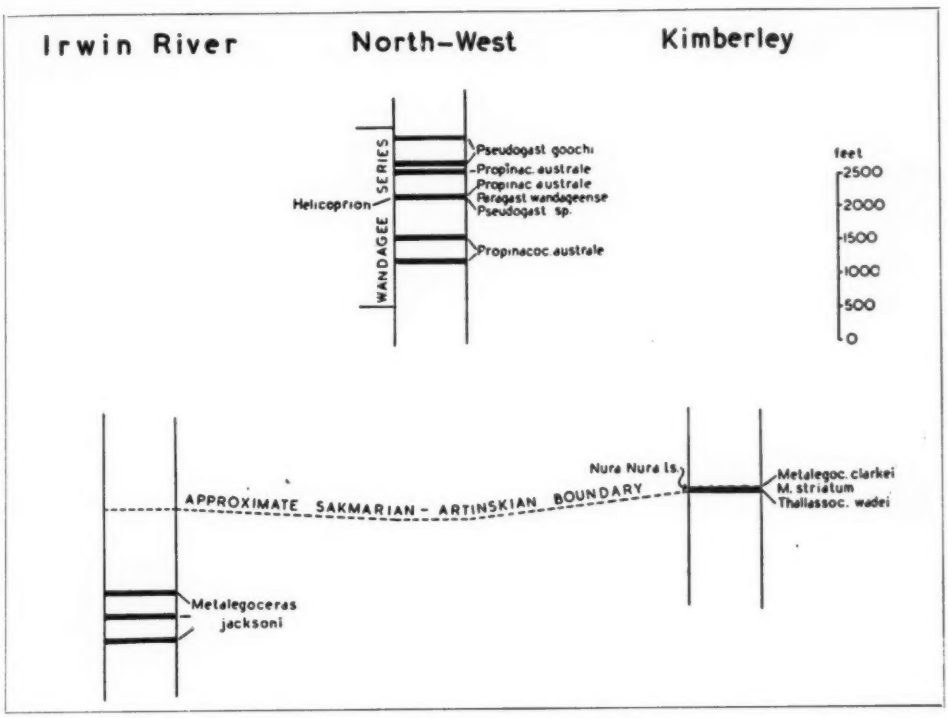


FIG. 2.—Stratigraphic relationships of Western Australian Permian ammonoid assemblages.

of *Thalassoceras* described by Smith (1927) is not similar to the Western Australian species of the genus. The closest similarity is afforded by the species of *Metalegoceras* in Timor and Western Australia, as has already been pointed out by previous authors. Also, *Propinacoceras australe* from Western Australia is rather similar to the Timor species, *P. simile* Haniel.

There is only one record of an occurrence of a Permian ammonoid elsewhere in Australia. In 1925, Whitehouse determined an "impression of a cephalopod (?) resembling *Girtyites*" from the basal beds at Mt. Britton in the Nebo district of Queensland. These beds, formerly regarded as part of the Middle Bowen series, were referred to the Lower Bowen series by Reid in 1930 (p. 63), though their exact place in the stratigraphical sequence is apparently unknown. David, in 1932 (Table D) referred to these beds as "*Paragastrioceras* (?) beds of Mt. Britton." It seems, therefore, possible that a species of *Paragastrioceras s. str.* (=*Girtyites* Wedekind) occurs in these Queensland beds.

The taxonomy and distribution of all the genera which are represented in Western Australia has been discussed quite recently by Miller and Furnish (1940). The writer finds that he has nothing to add to the very clear discussions presented by these two authors and their interpretation of the genera is here accepted. In particular, the reader's attention is called to Miller and Furnish's discussion of the mutual relationships of *Paragastrioceras* and *Pseudogastrioceras* on pages 82–84. Both genera are represented in

Western Australia by quite typical species.

In conclusion I wish to thank Dr. A. B. Walkom, of Sydney, for kindly supplying particulars of a species described in one of the papers which was not accessible in Perth libraries.

SYSTEMATIC DESCRIPTIONS

Family PROPINACOCERATIDAE

Genus PROPINACOCERAS Gemmellaro

The genus is known by a few species from Sakmarian and Artinskian strata of the Ural Mountains and from beds of similar or slightly younger age in Sicily, Croatia, Bokhara, and Timor. It reaches the climax of its development in the Crimea and in the Pamir region immediately after Artinskian time (Toumansky, 1931, 1935). The Western Australian *Propinacoceras australe* belongs to the forerunners of these post-Artinskian faunas.

PROPINACOCERAS AUSTRALE
Teichert, n. sp.
Plate 35, figures 2–7

Description of holotype (no. 20145).—The holotype is a limonitized specimen which represents the greater part of one full volution of a phragmocone. The living chamber is missing, but it seems nevertheless that the specimen had about reached maturity. The conch is fairly large and discoidal. The whorls are strongly compressed laterally, their flanks are almost parallel. The ventral side is very slightly rounded, with a narrow depressed zone in the middle. Between this depressed zone and the ventrolateral shoulders there is on each side a row of prominent transverse ridges, which run slightly backward from the depressed zone and fade out on the lateral side of the ventrolateral shoulders. The umbilicus is very small, and the umbilical wall is not sharply set off from the flanks. There is an indication that the flanks were covered by faint sigmoidal ribs, which are visible in one place near the ventrolateral shoulders.

The dimensions of the specimen are as follows:

Greatest diameter	60.5 mm.
Greatest height of last whorl	37 mm.
Greatest height of last whorl above preceding whorl	26 mm.
Greatest width of last whorl	15.5 mm.

The external suture can be described as follows: The external saddle is long and trifid and has perfectly straight sides. The external saddle is rather broad and modified by three secondary elements. The two lateral lobes and the first four auxiliary lobes are bifid, and the second lateral lobe is larger than the first one. Further details appear from figure 3.

Additional material.—A fragment of a smaller specimen from approximately the same horizon as the holotype shows the presence of faint transverse ribs on the flanks of the shell more clearly. The ribs are directed backward and confined to the region near the ventrolateral shoulders.

EXPLANATION OF PLATE 35

All specimens except figures 1 and 11 came from the Permian Wandagee series near Wandagee Station, North-West Division, Western Australia. Figures 1 and 11 came from the Permian Nura Nura limestone at Nura Nura ridge, West Kimberley Division, Western Australia. The exact horizons and localities are given in the text. The specimens are deposited in the Department of Geology, University of Western Australia, Crawley, West Australia.

FIGS. *1*—*Metalegoceras striatum* Teichert, n. sp. Lateral view of holotype (no. 20508), ×3. (p. 230)

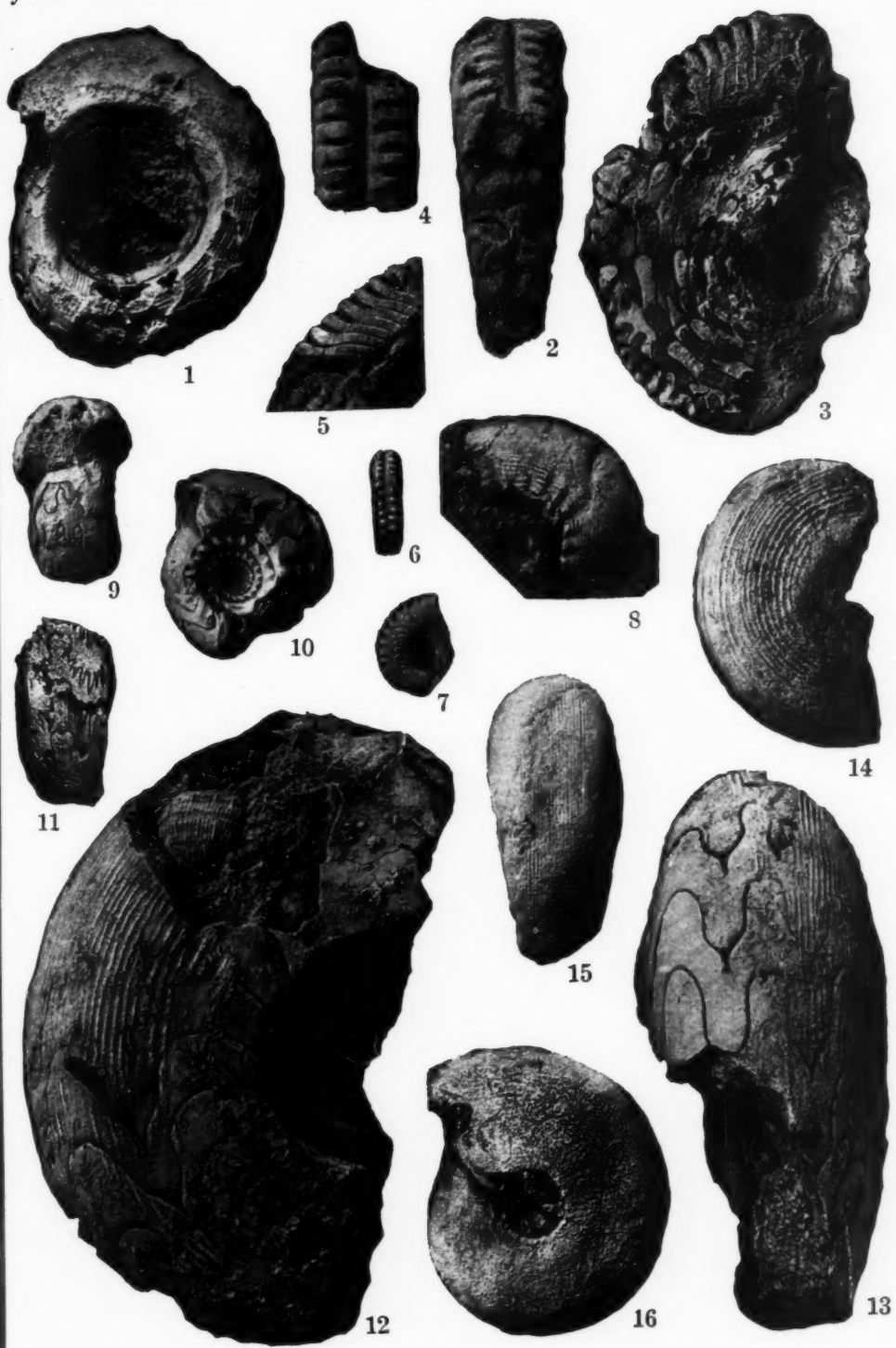
2–7—*Propinacoceras australe* Teichert, n. sp. *2*, *3*, Ventral and lateral views of holotype (no. 20145), ×1; *4*, *5*, ventral and lateral views of a large testiferous fragment (no. 20510), ×1; and *6*, *7*, ventral and lateral views of an immature specimen (no. 20509), ×2. (p. 224)

8—*Pseudogastrioceras* sp. Lateral view of an artificial cast made from a natural external mould (no. 20507), ×3. (p. 229)

9, *10*—*Paragastrioceras wandageense* Teichert, n. sp. Ventral and lateral views of holotype (no. 21042), ×1. (p. 226)

11—*Thalassoceras wadei* Miller. Ventral view of fragment of large specimen (no. 20143), ×1. (p. 231)

12–16—*Pseudogastrioceras goochi* Teichert, n. sp. *12*, *13*, Lateral and ventral views of holotype (no. 20504), ×1; *14*, lateral view of smaller specimen (no. 20506), ×1; and *15*, *16*, ventral and lateral views of another relatively small specimen (no. 20505), ×1. (p. 227)



Teichert, Permian Ammonoids

UNIV. OF MICH.

At a still lower horizon a fragment of a specimen was found which must have exceeded the holotype in size. The width of its whorl must have been slightly greater than 17.5 mm. This fragment is testiferous. The transverse ridges on the ventral side are perpendicular to the ventrolateral shoulders and very sharp and narrow sigmoidal ribs are visible on the flanks of the shell (pl. 35, figs. 4, 5).

A number of immature specimens were found at a still lower horizon (lowest North-West ammonoid horizon of fig. 2). In these the ventral ridges are not yet fully developed. The venter is ornamented by two rows of small rounded nodes on each ventrolateral shoulder, which alternate in position (pl. 35, figs. 6, 7). The surface of the flanks is ornamented by very shallow sigmoidal ribs whose number corresponds to that of the

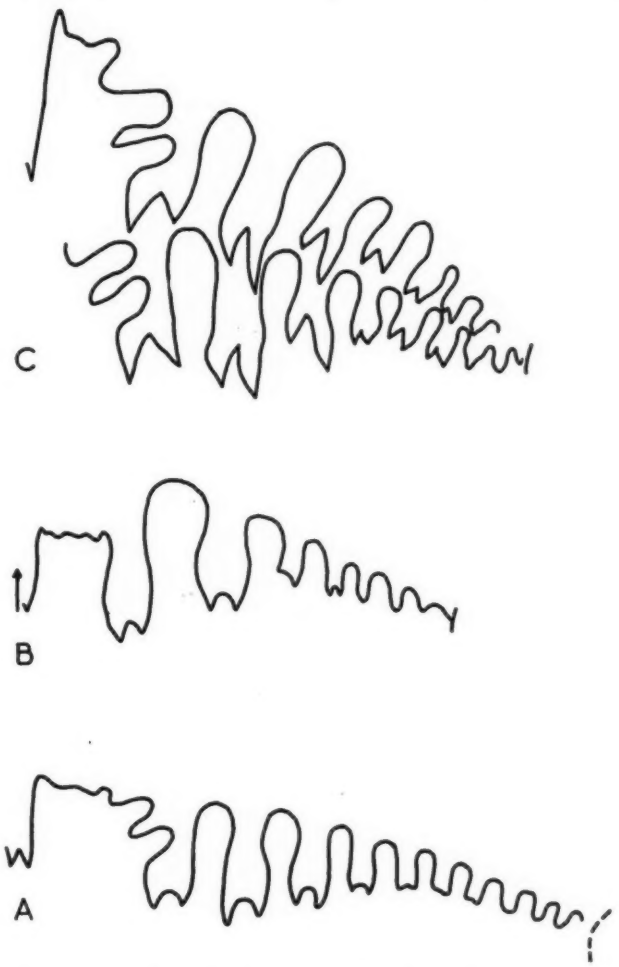


FIG. 3.—Diagrammatic representations of sutures of species of *Propinacoceras*.
(A) *P. simile* Haniel, from the Bitaoeni beds of Timor, ×3.5.2, (adapted from Haniel). (B) *P. australe* Teichert, n. sp., based on immature specimen (no. 20144b) at a whorl height of 6 mm, from just below the main *Calceolispongia* horizon of the *Calceolispongia* stage of the Wandagee series, Minilya River, west of Coolkilya Pool, ×16. (C) *P. australe* Teichert, n. sp., mature suture, based on holotype (see pl. 35, fig. 3), ×2¾.

nodes on the ventrolateral shoulders. The suture of one of these immature specimens is represented on figure 4B. It will be seen that the first lateral saddle is not yet developed at this stage.

Occurrence.—Holotype: Near base of *Linoproductus* stage of Wandagee series, at approximately the same horizon as *Helicoprion davisii*, on west limb of syncline north of Wandagee Hill, 1475 yards north of Wandagee-Minilya road, Coolkilya Paddock, Wandagee Station. Other specimens: One specimen at approximately the same horizon on east limb of same syncline, a few yards north of Wandagee-Minilya road. Several other specimens were found in the sequence of the east limb of the syncline exposed along the Minilya River, west of Coolkilya Pool, where immature specimens (pl. 35, figs. 6, 7) occur in the lower part of the *Calceolispongia* stage of the Wandagee series immediately below the main *Calceolispongia* horizon (lowest North-West horizon in fig. 2), and in the upper part of the same stage (pl. 35, figs. 4, 5) at a horizon which is characterized by a very large species of *Calceolispongia;* also at about the main part of the *Calceolispongia* stage in outcrops 1⅓ miles south of Coolkilya Pool, just south of an important E.W. fault. All these occurrences are in Coolkilya Paddock, Wandagee Station.

Remarks.—This species is very similar to *Propinacoceras simile* Haniel (1915, p. 34) from the Bitaoeni beds of Timor, from which it differs in the somewhat larger size of the first lateral lobe (see fig. 3) and in a somewhat different modification of the first lateral saddle. *Propinacoceras knighti* Miller and Furnish (1940, p. 42) from the Leonard formation of Texas is another very similar species, which, however, differs noticeably in the modification of the first lateral saddle and in the shape of the second lateral lobe. *Propinacoceras ajense* Maximova (1935, p. 288), *P. bonemanni* Toumansky and Bornemann (1937, p. 108) and *P. aktubense* Rhuzhencev (1939), are also similar to *P. australe*. All these species are of Artinskian age.

Family GASTRIOCERATIDAE
Genus PARAGASTRIOCERAS Tchernov

As Miller and Furnish have stated (1940, p. 83) this genus, in its properly restricted sense, is only known by the genotype *P. jossae* (Karpinsky) and probably by *P. kirghizorum* Voinova, both from the Artinskian beds of the Ural Mountains. The Western Australian species is associated with *Helicoprion davisii*.

PARAGASTRIOCERAS WANDAGEENSE
Teichert, n. sp.
Plate 35, figures 9, 10

Description of holotype (no. 20142).—The shell is subglobose with a semilunar whorl section which is almost three times as broad as it is high. The ventral surface is strongly convex, the dorsal area equally concave. The umbilicus is broad, open, equal to about one-half the diameter of the shell. It has rounded shoulders and a steep wall. The umbilical shoulder is ornamented by a great number of ridges directed obliquely forward. The ridges arise just inside the shoulder on the umbilical wall and fade out a short distance from the shoulder on the ventrolateral flanks. There are 18 of these ribs in one revolution. Remnants of the outer shell are preserved in replica in a few places and reveal the presence of rather weak longitudinal striae on the surface of the shell. Where the shell is 13 mm. wide, there seem to be about 10 striae in a distance of 3 mm. These longitudinal striae can also be seen on the inner volutions of the specimen, and it is probable that the entire shell was covered with them and that they were originally slightly stronger than in their present state of preservation.

The following measurements of the holotype can be given:

Diameter	26.2 mm.
Height of last whorl	8.6 mm.
Height of last whorl above venter of preceding whorl	6.0 mm.
Width of last whorl	17.4 mm.
Width of umbilicus	13.0 mm.

Only the external suture can be studied (fig. 4). It consists of five primary lobes and six primary saddles. The ventral lobe is wide and divided into two secondary lobes by a short secondary saddle, which is about half the length of the first lateral saddle. The first lateral lobes are rather broad and as long as the external lobe. The saddle between them is broad and evenly rounded. The second lateral saddle is broader and shorter than the

first one, and the second lateral lobe follows just inside the umbilical shoulder. It is short, slightly acute and simple.

Occurrence.—Two hundred yards north of Wandagee-Minilya Road, west side of syncline, north of Wandagee Hill. In lower part of *Lnoproductus* stage of Wandagee series, at approximately the same horizon as *Helicoprion davisii*. An additional specimen was found at the same horizon on the opposite side of the same syncline.

Remarks.—This species is remarkably similar to the genotype, *Paragastrioceras jossae* (de Verneuil), from which it differs in but a few not very outstanding features. De Verneuil states (Murchison, de Verneuil, Keyserling, 1845, p. 371) that in *Paragastrioceras jossae* the width of the umbilicus varies in different individuals and may be as wide as two-thirds of the diameter of the conch, and that the volutions are twice as wide as they are high. The umbilical "tubercules," actually more like ribs as in *P. wandageense*, are well described by de Verneuil. He gives their number as twenty to a revolution, but in the small specimen figured on plate 26, figure 2c, I count only seventeen to eighteen in a revolution. The holotype of *P. wandageense* is almost indistinguishable in shape and ornamentation from this smaller specimen of *P. jossae*. The only difference which can be seen between these two specimens is in the slightly different shape of the first lateral lobe (fig. 4), which is somewhat constricted adorally in *P. jossae*, whereas that of *P. wandageense* is wide open (see also Karpinsky, 1892, p. 70). Another difference is possibly that the ridges on the umbilical shoulder are slightly stronger in *P. jossae* as also appears from a comparison of the specimen figured by Wedekind (1917, plate 17, figs. 13, 14). *P. kirghizorum*, recently described by Voinova (1934) has comparatively much higher volutions.

Genus PSEUDOGASTRIOCERAS Spath
PSEUDOGASTRIOCERAS GOOCHI, Teichert, n. sp.
Plate 35, figures 12–16

Description of holotype (no. 20504).—The holotype of this species represents about one-half of a rather large phragmocone. The dimensions are as follows:

Greatest diameter	98 mm.
Greatest height of last whorl	45 mm.
Greatest width of last whorl	40? mm.
Diameter of umbilicus	32 mm.

The venter of the conch is evenly rounded, almost semicircular in outline. The flanks

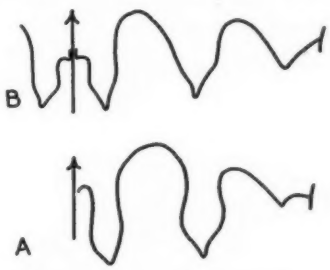


FIG. 4.—Diagrammatic representations of external sutures of species of *Paragastrioceras*. (A) *P. wandageense* Teichert, n. sp., based on the holotype (see pl. 55, figs. 9, 10), from the Wandagee series, North-West District, Western Australia, ×2.5. (B) *P. jossae* (de Verneuil), from the Artinskian of the Ural Mountains (adapted from Murchison, de Verneuil, and von Keyserling), ×4.

are almost flat, except a very slightly depressed zone in the middle between the ventrolateral and the umbilical shoulders. The flanks are diverging slightly and the greatest width of the whorls is attained at the umbilical shoulders. The umbilical wall is steep, smooth, and at right angles to the flanks. The surface of the conch is marked by closely spaced longitudinal ribs, which are low and flat. They seem to be less prominent in the vicinity of the umbilical shoulders than on the ventrolateral and ventral sides. There is no sign of any transverse or umbilical ornamentations or constrictions.

The sutures are those typical of *Pseudogastrioceras*. A noteworthy feature is that the two branches of the external lobe have a more symmetrical appearance than in most other species of the genus (fig. 5).

Additional material.—From a somewhat higher horizon (the highest ammonoid horizon in fig. 2) a small specimen was obtained which apparently belongs to the same species (pl. 35, figs. 15, 16). Its measurements are:

Greatest diameter	45.5 mm.
Height of last whorl	23 mm.
Height of last whorl above preceding whorl	13 mm.
Width of last whorl	23? mm.
Width of umbilicus	10 mm.

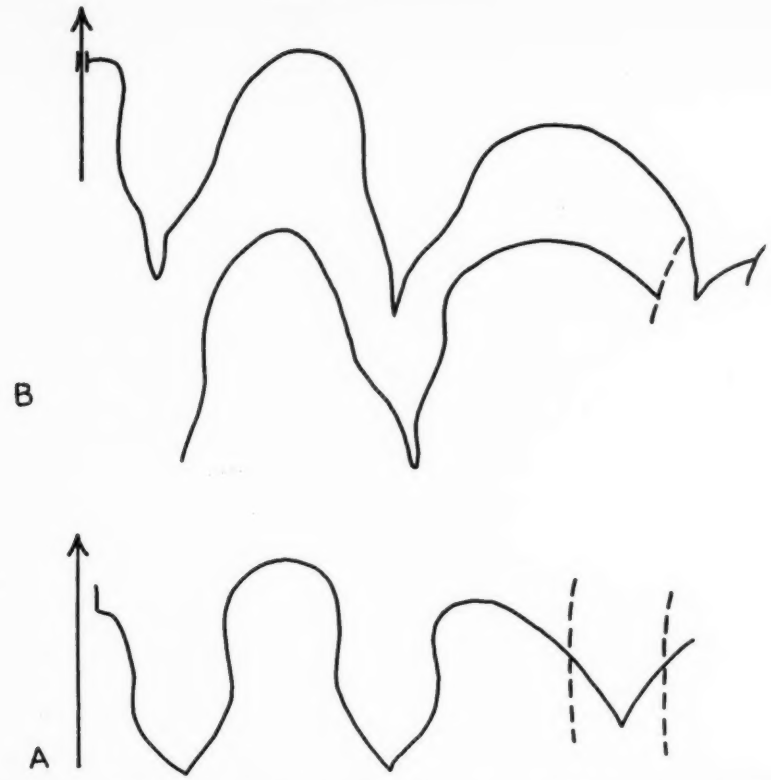


FIG. 5—Diagrammatic representations of external sutures of species of *Pseudogastrioceras*.
(A) *P. seussi* (Karpinsky), from the Artinskian of the Ural Mountains (adapted from Karpinsky, 1892), ×2¾.
(B) *P. goochi* Teichert, n. sp., based on the holotype (see pl. 35, figs. 12, 13) from the Wandagee series, North-West Division, Western Australia. ×2.

The flanks of this specimen are still flatter than those of the holotype, and the depression in the middle is almost imperceptible. The longitudinal ribbing is faint, because not so much of the shell is preserved. This specimen has very faint and short umbilical ribs, which disappear on the flanks at a distance about 2 mm. from the umbilical shoulder.

A fragment of yet another specimen (plate 35, fig. 14) of about the size of the preceding one shows the depressed zone on the flanks more pronouncedly. Also, the longitudinal ribs are well shown in this specimen; they are absent from the immediate vicinity of the umbilicus.

The species is named in honor of Mr. G. Gordon Gooch, Wandagee Station, North-West District.

Occurrence.—Holotype: Somewhat above the basal beds (approximately *Thamnopora-Cleiothyridina* zone) of the *Linoproductus* stage of the Wandagee series, near mouth of northeastern gully of Wandagee Hill, on fence dividing Shed and Mungadan Paddocks, Wandagee Station. Other specimens: In the upper part of the *Linoproductus* stage, associated with *Dybowskiella*, *Calceolispongia* and *Helodus*, 300 yards east of mouth of southeastern gully of Wandagee Hill, Mungadan Paddock, Wandagee Station (pl. 35, figs. 15, 16). Among the pebbles at the mouth of the northwestern gully of Wandagee Hill, Mungadan Paddock, Wandagee Station; (this specimen, pl. 35, fig. 14, may come from the base of the Kennedy sandstone, but because of uncertainty of its derivation, the occurrence is not shown in fig. 2). A

rather large, though badly crushed specimen came from the lower part of the *Linoproductus* stage, from a horizon equivalent to that of the holotype, on the west side of the syncline in Coolkilya Paddock (north of Wandagee Hill), 1¼ miles north of the Wandagee-Minilya road. A small fragment came from the same horizon, nearer to the road; and finally, a very poor fragment was found in the same horizon in the fault block to the east of this syncline, near the Wandagee-Minilya road, a little over 1 mile west of the southeast corner of Coolkilya Paddock.

Remarks.—*Pseudogastrioceras goochi* is most closely related to *Pseudogastrioceras suessi* Karpinsky (1889) and *P. karpinskii* Frédérix (1915) from the Artinskian of the Ural Mountains. From the former it is distinguished by a narrower umbilicus, and from the latter (Frédérix, 1915, p. 91) by the shape of the sutures, the second lateral lobe of *P. karpinskii* being considerably inflated. The differences of the sutures of *P. goochi* and *P. suessi* are shown in figure 5. From the otherwise very similar *P. roadense* (Böse) of Texas the Western Australian species differs in its wider umbilicus, and the same feature also distinguishes it from the genotype, *P. abichianum* (Möller). All these species form a group of closely related forms within the genus *Pseudogastrioceras*, which are characterized by rather strongly compressed whorls, longitudinal ribs, and the absence of conpsicuous transverse ornamentation and of umbilical ribs or nodes. For detailed discussions of these species see Plummer and Scott, 1937, pp. 227–228, and Miller and Furnish, 1940, pp. 89–91.

PSEUDOGASTRIOCERAS sp.
Plate 35, figure 8

An external mould of a portion of a small conch (no. 20507) is so different from any specimens here referred to *Pseudogastrioceras goochi* that it seems to represent another species, which, however, cannot be fully described. The diameter of this conch has been about 11 mm. The surface was covered by weak longitudinal striae, which are distributed evenly over the ventral and lateral sides. The cross-section of the whorls must have been depressed dorsoventrally. The umbilicus is ornamented by distinct ribs, which continue for some distance on the flanks. Some of the depressions between these ribs continue as constrictions on the flanks and on the venter, forming a deep sinus as they cross the latter, similar to conditions in *Pseudogastrioceras altudense* (Böse) (see Miller and Furnish, 1940, pl. 14, figs. 1–6). The longitudinal ribbing of the Western Australian specimen is, however, much finer.

The depressed whorl section and the presence of constrictions of the conch will serve to distinguish this species from *Pseudogastrioceras goochi*.

Occurrence.—Basal beds of *Linoproductus* stage of Wandagee series, east limb of syncline north of Wandagee Hill, about 1 mile north of Wandagee-Minilya road, Coolkilya Paddock, Wandagree Station, North-West Division.

Genus METALEGOCERAS Schindewolf

At the present moment nothing can be added to our knowledge of *M. clarkei* from the Nura Nura limestone, which has been exhaustively discussed by A. K. Miller in 1936. Remarks on *Metalegoceras jacksoni* and the description of a new species, *M. striatum*, follow below. The sutures of all Western Australian and some foreign species of *Metalegoceras* are compared in figure. 6.

METALEGOCERAS JACKSONI (Etheridge)

Nothing can be added at present to the elaborate redescription of this species by Miller (1932). Among the numerous specimens kept in the collections of the Department of Geology of the University of Western Australia, there are, however, some which are remarkable for their size. The measurements of the largest specimen are as follows:

Largest diameter	205 mm.
Greatest width	125 mm.
Height at last whorl	92 mm.
Height of last whorl above venter of preceding whorl	50 mm.
Width of umbilicus	88 mm.

About four-fifths of the last volution are occupied by the living chamber, which, however, is not preserved in its entire length. The dimensions of the original specimen, therefore, must have been still larger, and *Metalegoceras jacksoni* is no doubt among the largest known Palaeozoic ammonoids.

Occurrence.—*Metalegoceras* series of the Irwin River area, Western Australia. The species occurs here in fair numbers, but is not as abundant as is frequently believed.

Holotype.—No. 11980, Department of Geology, University of Western Australia (R. Etheridge, Geol. Surv. West. Austr., Bull. 27, 1907, pl. 9, figs. 1–3).

METALEGOCERAS STRIATUM
Teichert, n. sp.
Plate 35, figure 1

Description.—Only one specimen known at present (no. 20508). Shellr ather evolute, with very much depressed whorls whose maximum width is 11 mm. and their maximum height 3 mm. The umbilicus is wide and equals in width about two-thirds the diameter of the shell. The umbilical wall forms an acute angle with the ventro-lateral flanks. The venter is evenly rounded. The surface of the mould is ornamented by fine longitudinal striae, about seven to eight in a distance of 2 millimeters where the shell is 10 mm. wide. These are crossed by still finer transverse striae, about eight in 1 millimeter, which cross the venter in a slightly convex course.[1]

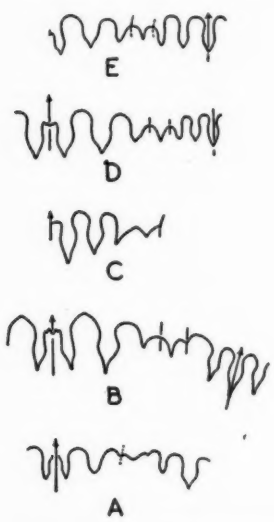


FIG. 6—Diagrammatic representations of sutures of species of *Metalegoceras*.
(A) *M. distale* Ruzhencev, from the Sakmarian of the Ural Mountains (adapted from Ruzhencev, 1938), ×4.5.
(B) *M. jacksoni* (Etheridge), from the *Metalegoceras* series, Irwin River, Western Australia (adapted from Miller, 1932), ×1.
(C) *M. striatum* Teichert, n. sp., from the Nura Nura limestone, Kimberley Division, Western Australia, ×2.5.
(D) *M. clarkei* Miller, from the Nura Nura limestone, Kimberley District, Western Australia (adapted from Miller, 1936), ×2.5.
(E) *M. evolutum* (Haniel), from the Bitoeni beds of Timor (adapted from Haniel), ×1.

Only the external sutures are visible (fig. 6). They consist of one external lobe, of two pairs of lateral lobes, and of one pair of umbilical lobes. The ventral saddle subdividing the ventral lobe cannot be seen anywhere in the specimen. That half of the ventral lobe which is adjacent to the ventral saddle is constricted adorally and drawn out into a long point adapically. The first lateral saddle is evenly rounded adorally and constricted in the middle. The first lateral lobe resembles the branches of the external lobe. It is likewise drawn out to a narrow point, but is shorter. The second lateral saddle is shorter, comparatively wider and less constricted. The second lateral lobe is short and unconstricted. The umbilical lobe seems to be quite short, but is not very well preserved anywhere in the specimen.

Occurrence.—Nura Nura Ridge, West Kimberley Division, Western Australia. In the top part of the Nura Nura limestone.

Remarks.—The surface ornamentation of this species is very different from that of any other species of the genus with the exception of *Metalegoceras colemanense* Plummer and Scott (1937, p. 2828) from the Wichita group of Texas and of *M. sogurense* Ruzhencev

[1] It should be noted that the preservation of this specimen corresponds to what in German palaeontological literature is known as a "Skulptursteinkern," that is a mould in which traces of the external ornamentation of the shell have been superimposed, during the process of fossilization, on the internal mould. Across the venter of the specimen the sutures stand out in slight relief above the surface of the ornamented mould. On the umbilical wall, however, the sutures are not visible and we have here a replica preservation of the original surface of the shell. Instead of going into details as to the origin of such moulds I can here refer to W. Quenstedt's recent treatise on the subject (1928). Quenstedt studied the process of "Skulptursteinkern" formation in lamellibranchs, but his results are also applicable to other shells.

(1933) from the Artinskian of the Urals. In these species, however, the transverse striae or ribs are more prominent and the longitudinal striae are very fine. The sutures of the two species are, moreover, rather different. The most remarkable feature of the sutures of *Metalegoceras striatum* is the strong development of the branches of the external lobe, which are comparatively more strongly developed in this species than in any other known species of the genus. On account of these peculiarities the species is not easily confused with any other form.

Family THALASSOCERATIDAE
Genus THALASSOCERAS Gemmellaro

Eight species of this genus are known: *T. phillipsi* Gemmellaro and *T. varicum* Gemmellaro from the Sosio beds of Sicily, *T. khabakovi* Voinova from the Artinskian of the South Urals, *T. gemmellaroi* Karpinsky from the Sakmarian and Artinskian of the Urals, an undescribed Sakmarian species (Ruzhencev, 1938), an unnamed species from the Leonard formation of Texas (Miller and Furnish, 1940, p. 107), *T. wadei* Miller from the Nura Nura limestone of Western Australia, and *T. dieneri* Smith from the Bitaeoni beds of Timor.

THALASSOCERAS WADEI
A. K. Miller
Plate 35, figure 11

Thalassoceras wadei A. K. MILLER, *1936*, Jour. Paleont., vol. 10, pp. 685–687, pl. 92, figs. 8–12.

The species has been well described by its author and little can be added here. As Miller suspected, the two specimens at his disposal were immature forms. Among the new material collected by me is a fragmentary internal mould of part of a bigger specimen (no. 20143) whose width was at least 16 mm. Unfortunately, only part of the mature suture can be studied in this specimen. It shows, however, that the external lobe of the species at maturity develops a greater number of secondary elements than any of the specimens described by Miller. This is illustrated by text figure 7, which requires no further explanation.

It seems that the Sakmarian and Artinskian species of *Thalassoceras* including *T. wadei*, are characterized by the rather simple shape of the secondary elements of the lobes and that the evolutionary trend was towards complexity and irregularity of these elements as shown in the geologically younger genotype, *T. phillipsi*, from the Sosio limestone.

Occurrence.—Nura Nura Ridge, West Kimberley Division, Western Australia. In the top part of the Nura Nura limestone.

Holotype.—No. 19988, Department of Geology, University of Western Australia.

FIG. 7—Diagrammatic representation of ventral and ventrolateral part of mature suture of *Thalassoceras wadei* Miller, based on a fragment (pl. 35, fig. 11) from the Nura Nura limestone, Kimberley Division, Western Australia, ×3.

(A. K. Miller, Jour. Paleont., vol. 10, 1936, pl. 92, fig. 11).

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MANUSCRIPT RECEIVED BY THE EDITOR NOVEMBER 1, 1940.

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FORAMINIFERA FROM THE CHARCO AZUL FORMATION, PLIOCENE, OF PANAMA

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ABSTRACT—The foraminiferal fauna indicates the Pliocene age of the Charco Azul formation of Panama as based on the 36 species and seven varieties described here. Eight of the species and five of the varieties are new.

INTRODUCTION

THE STUDY of the microfauna of the Charco Azul formation is of particular interest, not only for the light it throws on the age of those beds, but for the interesting geographical relationships shown with other regions. The material which forms the basis for this paper was collected from the type locality of the Charco Azul formation by R. A. Terry, who has suggested the name, while working on the geology and stratigraphy of western Panama. The sample, obtained from the east side of the Burica Peninsula on the Pacific Coast of Panama near the Cost Rica boundary, is a poorly consolidated, fine-textured, gray siltstone which contains various megafossils and abundant Foraminifera.

Without entering into a detailed discussion of the stratigraphy of the Burica Peninsula, which is being adequately covered by A. A. Olsson in connection with his study of the megafossils of the area, we will state here that the Charco Azul formation is believed to be Pliocene on the basis of the regional relationships and the faunal aspects. It is overlain by Armeulles formation of Pleistocene age, and underlain by the upper Miocene, Limones shale. The Penitas formation, occurring to the northwest, is believed to be correlative with Charco Azul.

Foraminifera, which comprise practically the only micro-organisms in the Charco Azul, are exceptionally abundant, but certain families are notably absent, particularly the Miliolidae and the Textulariidae. On the other hand there is a great abundance of the genera *Bolivina*, *Valvulineria*, and also many genera of the family Orbulinidae. Since the latter are largely pelagic forms, their presence in abundance need not be considered diagnostic, but at the same time they suggest a depth of water of over 100 fathoms if in an open sea, as their tests would probably not accumulate in shallower seas due to wave action, unless in a lagoonal environment. *Bolivina* is particularly characteristic of a depth of approximately 400 fathoms. The other genera represented are almost all deep water forms. *Valvulineria* has been considered a shallow water type, but from the delicate nature and extravagant ornamentation of the species here described, it seems that the genus was equally at home in deeper water. Species have been described by Cushman (1927) from depths as great as 810 fathoms. Thus it seems reasonable to assume that the clays of the Charco Azul formation were deposited in depths of at least 400 fathoms, in temperate to cool water. The lack of representation of the Miliolidae and Textulariidae bears out the preceding conclusion admirably as they are families with genera that are known to be primarily associated with a habitat of warm, shallow water.

In determining the age of the Charco Azul formation on the basis of the Foraminifera, some difficulty was encountered since about 50 per cent of the species have been reported from recent collections. On the other hand, the most abundant specimens belong to the genus *Valvulineria*, which is known to occur in great numbers in the Miocene and Pliocene of California and is less persistent in the Pleistocene and Recent. *Cassidulina californica*, which is very abundant in the Charco Azul, is likewise more diagnostic of the Tertiary than of the Quaternary formations of California. Also many of the species of *Bolivina* and of the other genera present in this collection are principally allied to those of Pliocene age. The summation of the evidence of the microfossils indicates that the Charco Azul formation is of Pliocene age. Olsson's conclusions are similar, both as to

age and faunal relationships, while Terry also considers it Pliocene on the basis of field observations.

A study of this fauna (Schuchert, 1935, pp. 556–591) adds some information to a problem on which there has been considerable discussion. It is the question as to when the last marine connection between the Caribbean Sea and the Pacific Ocean through Panama and Costa Rica was closed. Bearing on this subject, it should be noted that 25 to 30 per cent of the species herein described have been found in the Los Angeles Basin. Likewise, a somewhat smaller percentage comprises species peculiar to the Recent Pacific of North and South America. Disregarding the universally distributed pelagic genera such as *Globigerina* and *Orbulina*, no species occur here that are also found in deposits of Atlantic regions and have not been found to occur in the Atlantic Miocene. It would seem, therefore, that this microfauna bears out the opinion of W. D. Mathew (1906), R. E. Dickerson (1917), and Holmes and Simpson (1931) that the Panama-Costa Rica Passage has been uninterruptedly closed since the end of Miocene time; however, our information favors even an earlier date for the initial closing of the seaway.

This paper does not represent a complete faunal list of the Foraminifera on the Charco Azul formation, but rather comprises a selected faunule, in which the more common and representative species are described.

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SYSTEMATIC DESCRIPTIONS

Phylum PROTOZOA
Class RHIZOPODA
Order FORAMINIFERA
Family NODOSARIIDAE
Schultze, 1854
Genus ROBULUS Montfort, 1808

ROBULUS CUSHMANI var. PROCEDENDUS
Coryell and Mossman n. var.
Plate 36, figures 1–2

Test lenticular, close-coiled, equally biconvex, thick, provided with a large central umbo of clear shell material; periphery with a prominent limbate keel; chambers seven or eight in the last whorl; sutures limbate, broadest and tending to be slightly depressed nearer periphery, meeting the umbo tangentially; wall hyaline, smooth, very finely perforate; aperture radiate, with an elongate slit on the apertural face, which has several slight ridges below the aperture and parallel to the sides of the face.

This variety evidently represents a more advanced stage of the species, in which the raised sutures of the earlier part are accelerated out and the last septal face becomes more complex.

Maximum diameter of holotype, 0.66 mm.; thickness, 0.34 mm.

Holotype.—Columbia University Micropaleontology Collection.

Family NONIONIDAE Reuss, 1860
Genus PULLENIA Parker and Jones, 1862

PULLENIA MALKINAE
Coryell and Mossman, n. sp.
Plate 36, figures 3–4

Test nautiloid, bilaterally symmetrical, completely involute, somewhat inflated, the height being about twice the width in apertural view; periphery rounded; chambers seven or eight in the last whorl, regularly increasing in size; sutures curved, distinct, but only very slightly depressed; wall hyaline, smooth, very finely perforate; aperture a low arched slit at the base of the last septal face, extending from umbilicus to umbilicus, with a slightly curved upper lip; last septal face smoothly concave.

Maximum diameter of holotype, 690. mm.; thickness 0.38 mm.

Holotype.—Columbia University Micropaleontology Collection.

Family ROTALIIDAE Reuss, 1860
Genus GLOBOROTALIA Cushman, 1927

GLOBOROTALIA MENARDII (d'Orbigny)
Plate 36, figure 5

Rotalia menardii D'ORBIGNY, *1826*, Ann. Sci. Nat., vol. 7, p. 272, Modeles no. 10.
Globorotalia menardii CUSHMAN, *1927*, Scripps Inst. Oceanography Bull., vol. 1, no. 10, p. 175, no. fig.

Test rotaloid, biconvex, low, all chambers

visible dorsally, only the last whorl visible on the ventral side; periphery acute, broadly carinate; chambers slightly convex, closely appressed, four to six in the last whorl; sutures depressed, slightly limbate dorsally; wall calcareous, perforate; aperture a slit extending from the umbilicus part way to the periphery, with a distinct valvular lip.

Cushman states that the representatives of the species in his Scripps material came from the stations in warmer water off Southern California and Central America, which would be correlatable with its occurrence in this collection.

Maximum diameter of figured specimen, 0.85 mm.; thickness, 0.30 mm.

Hypotype.—Columbia University Micropaleontology Collection.

Genus VALVULINERIA Cushman, 1926

VALVULINERIA INAEQUALIS
(d'Orbigny)
Plate 36, figure 6

Valvulina inaequalis D'ORBIGNY, *1839*, Voy. Amer. Merid., vol. 5, pt. 5, p. 48, pl. 7, figs. 10–12.

Valvulineria inaequalis CUSHMAN, *1927*, Scripps Inst. Oceanography Bull., vol. 1, no. 10, p. 161, pl. 4, figs. 9, 10.

Test rotaloid, unequally biconvex, dorsal side evolute, flattened; ventral side involute, inflated, umbilicate; periphery rounded; chambers seven to nine in the last whorl, rapidly enlarging in size and tending to become evolute; sutures nearly straight, flush dorsally, slightly depressed towards the umbilicus ventrally; test calcareous, hyaline, finely perforate; aperture an arched slit at the base of the last septal face from the umbilicus to the periphery, with the umbilicus covered by a large flap extending from the base of the last chamber.

This species seems to be practically identical with specimens figures by d'Orbigny and by Cushman, indicating by its lack of evolutionary change that it may represent a mature stage in the development of the genus.

Maximum diameter of figured specimen, 1.10 mm.; maximum thickness, 0.49 mm.

Hypotype.—Columbia University Micropaleontology Collection.

VALVULINERIA INFLATA
(d'Orbigny)
Plate 36, figures 7–9

Valvulina inflata D'ORBIGNY, *1839*, Voy. Amer. Merid., vol. 5, pt. 5, p. 48, pl. 7, figs. 7–9.

Valvulineria inflata CUSHMAN, *1927*, Scripps Inst. Oceanography Bull., vol. 1, no. 10, p. 161, pl. 5, fig. 3.

Test rotaloid, dorsal side flattened, spire depressed; ventral side convex, umbilicate; periphery rounded; chambers seven to nine in the last whorl, inflated ventrally; sutures curved, depressed; test calcareous, coarsely perforate; aperture an arched slit at the base of the last septal face, extending from the umbilicus, where it is covered by a valvular flap, part way to the periphery.

This species as found in the Charco Azul formation seems to be closely allied to the recent forms of d'Orbigny from Chile and Peru, and to those of Cushman from off the California coast, and thus represents an earlier appearance of the species.

Maximum diameter of the figured specimen, 0.75 mm.; thickness, 0.41 mm.

Hypotype.—Columbia University Micropaleontology Collection.

VALVULINERIA JOHNSONI
Coryell and Mossman n. sp.
Plate 36, figures 10–12

Test rotaloid, unequally biconvex; dorsal side evolute, nearly plane, slightly umbilicate; ventral side involute, strongly convex, umbilicate; periphery angled, with the chambers each produced on the dorsoperipheral margin to form a marginal lobe or keel; chambers usually seven in the last whorl, strongly inflated ventrally, the last comprising about one-third of the test in ventral view, and with a large flap extending over the umbilical region; sutures curved, depressed, dorsally limbate in early part; test calcareous, coarsely perforate; aperture an arched slit midway between periphery and umbilicus and extending under the umbilical flap.

The most outstanding characteristic of this species is the produced, lobed peripheral edge of the chambers. In other respects it is most like *Valvulineria californica* Cushman (1926) however our specimen has later chambers, larger and more involute. Maxi-

mum diameter of holotype, 0.82 mm.; thickness, 0.41 mm.

Holotype.—Columbia University Micropaleontology Collection.

VALVULINERIA SCINTILLANS
Coryell and Mossman n. sp.
Plate 36, figures 13–15

Test rotaloid, unequally biconvex; dorsal side completely evolute, very slightly convex; ventral side involute, convex, umbilicate; periphery angled, usually with a slight keel formed by the marginal carina; chambers seven to nine in the last whorl, regularly increasing in size, ventrally inflated, and each partially overlapping the previously formed one, the last chamber having flaplike extension over the umbilicus; sutures curved, somewhat limbate, ventrally depressed, and with an area of clear calcite extending out from the umbilicus part way along the sutures giving a stellate effect; sutures dorsally composed of clear calcite, becoming tubulated towards the periphery, and continuing around the peripheral margin of the chambers as a marginal border or carina; test hyaline, coarsely perforate except for a large, circular, transparent area on the last septal face on the ventral side above the aperture; the aperture an arched slit at the base of the last septal face, extending from the umbilicus, where it is covered by the flap, to about halfway to the periphery.

There seems to be some variation within the species as to the presence of the carina bordering the chambers. Specimens have been observed which lack this character on one or two chambers variously located in the whorl, but with the majority of the chambers carinated.

This species represents a considerable departure from the type of the genus in its angled and carinate periphery and the clear, *Baggina*-like area on the last septal face, in which characteristic it resembles *Valvulineria pauciloculata* Cushman (1935), showing, however, more chambers to a whorl on the dorsal side. It may be that these characters are of sufficient importance to be of generic value, but the fact that mutations from this species approach the more normal form of the genus preclude the erection of a new genus here.

This species has very close affinities with *Valvulineria hitchcockae* Galloway and Wissler (1927) but can be easily differentiated from it on the more dorsal location of the keel, the less convex dorsal side, and the more prominent clear area in the last septal face. The structure of the carina is also significant.

Maximum diameter of holotype, 0.90 mm.; maximum thickness, 0.44 mm.

Holotype.—Columbia University Micropaleontology Collection.

VALVULINERIA SCINTILLANS var. SINECARINA
Coryell and Mossman, n. var.
Plate 36, figures 16–18

Test rotaloid, unequally biconvex; dorsal side completely evolute, very slightly convex; ventral side involute, convex, umbilicate; periphery angled; chambers seven to nine in the last whorl, regularly increasing in size, ventrally inflated, and each partially overlapping the previously formed one, the last chamber having a flaplike extension over the umbilicus; sutures curved, somewhat limbate, ventrally depressed and with an area of clear calcite extending out from the umbilicus part way along the sutures, giving a stellate effect, sutures dorsally composed of clear calcite; test hyaline, coarsely perforate, except for a large circular, transparent area on the last septal face on the ventral side above the aperture, the latter being an arched slit at the base of the last septal face, extending from the umbilicus, where it is covered by the flap, to about halfway to the periphery.

This variety differs from the type of the species in the absence of the marginal carina or border around the chambers, the periphery being angulated, however.

Maximum diameter of the holotype, 0.48 mm.; thickness, 0.27 mm.

Holotype.—Columbia University Micropaleontology Collection.

Genus EPISTOMINA Terquem, 1883
EPISTOMINA BRADYI Galloway and Wissler
Plate 36, figure 19

Pulvinulina partschiana H. B. BRADY (not d'Orbigny), *1884*, Voy. Challenger Rep., Zool. vol. 9, p. 699, pl. 105, fig. 3.
Epistomina bradyi GALLOWAY and WISSLER, *1927*, Jour. Paleontology, vol. 1, no. 1, pp. 60–61, pl. 10, fig. 1.

Epistomina partschiana CUSHMAN (not d'Orbigny), *1927*, Scripps Inst. Oceanography Bull., vol. 1, no. 10, p. 163, figs. 4, 5.

Test rotaloid, biconvex periphery acute, keeled; eight to 10 chambers in the last whorl; sutures flush, limbate, meeting the broad ventral umbo tangentially; wall hyaline, smooth; aperture an elongate slit at the base of the last septal face between the umbo and the periphery, but somewhat nearer the periphery, also with a second aperture in each chamber below and parallel to the keel, and usually filled with clear calcite in the earlier chambers.

The relationship between the Pliocene specimens from California and those from this collection is very close, the only appreciable difference being in the number of chambers, which is usually only eight in the Panama specimens.

Maximum diameter of figured specimen, 0.69 mm.; maximum thickness, 0.32 mm.

Hypotype.—Columbia University Micropaleontology Collection.

Genus GYROIDINA d'Orbigny, 1826
GYROIDINA SOLDANII var. MULTILOCULA
Coryell and Mossman, n. var.
Plate 36, figure 20

Test rotaloid, dorsal side flat, ventral side high, umbilicate; chambers 12 to 14 in the last whorl; wall hyaline, smooth; sutures flush; aperture a slit at the middle of the base of the last septal face.

Maximum diameter of holotype, 0.40 mm.; thickness, 0.29 mm.

This variety differs from the typical specimens of the species principally in the additional number of chambers. *Gyrodina soldanii* d'Orbigny (1826) had eight to 10 chambers both in the original type and in most specimens subsequently referred to the species.

Holotype.—Columbia University Micropaleontology Collection.

Genus CIBICIDES Montfort, 1808
CIBICIDES TERRYI
Coryell and Mossman, n. sp.
Plate 36, figures 21–22

Test low, planoconvex; dorsal side evolute, flat or slightly concave; ventral side low, involute, slightly depressed in umbilical area with small round flat umbo; periphery keeled, slightly lobate in later part; chambers somewhat inflated ventrally, 14 to 16 in the last whorl; sutures limbate, depressed on ventral side; wall coarsely perforate; aperture on the periphery at the base of the last chamber, extending dorsally between the last two whorls for a distance of four or five chambers, with a distinct lip.

Maximum diameter of holotype, 0.90 mm.; thickness, 0.17 mm.

This species is quite similar in general appearance to *Cibicides lobatus* (d'Orbigny) as described and figured by Galloway and Wissler (1927), but differs in the greater number of chambers, the limbate sutures and keel, and the presence of an umbo.

Holotype.—Columbia University Micropaleontology Collection.

Genus PLANULINA d'Orbigny, 1826
PLANULINA ORNATA (d'Orbigny)
Plate 36, figure 23

Truncatulina ornata d'Orbigny, *1839*, Voy. Amer. Merid., vol. 5, pt. 5, p. 40, pl. 6, figs. 7–9.
Planulina ornata CUSHMAN, *1927*, Scripps Inst. Oceanography Bull., vol. 1, no. 10, p. 176, pl. 6, fig. 12.

Test planispiral, flat periphery subacute; chambers usually about 10 in the last whorl; sutures broadly limbate, very slightly depressed in later part; wall hyaline, very coarsely perforate; aperture an arched slit on the periphery, extending between the last two whorls on one side for a distance of two or three chambers.

Maximum diameter of figured specimen, 0.87 mm.; maximum thickness, 0.16 mm.

The number of chambers in this species seems to be rather variable. Evidently d'Orbigny's original specimen from the harbor of Valparaiso, Chile, where it was rare, was a young form, as he describes it as having seven chambers in the last whorl. Cushman figures a specimen with 11 chambers in the last whorl, while the present material yielded specimens with the number of chambers varying from seven to 12, but with 10 the most common number.

Hypotype.—Columbia University Micropaleontology Collection.

Family CHILOSTOMELLIDAE Brady, 1881
Genus CHILOSTOMELLA Reuss, 1850
CHILOSTOMELLA CZJZEKI Reuss
Plate 36, figures 24–25

Chilostomella czjzeki REUSS, *1850*, K. Akad Wiss. Denksch., vol. 1, p. 380, pl. 18, fig. 13.

Test ovate; two chambers to the last whorl, completely embracing except on the dorsal side opposite the aperture, where previous chambers are exposed; sutures faint; wall hyaline, smooth; aperture a long curved slit at the base of the last chamber, extending about half way around the circumference of the test, with a flaring lip.

Maximum height of figured specimen, 0.54 mm.; maximum diameter, 0.32 mm.

In his original figure of the species, from the Miocene, Reuss does not show an evolute dorsum, but his specimens were probably more opaque and less well preserved than these later forms. Brady figures a specimen (1884) which probably belongs to this species and shows an evolute dorsum. He refers it to *Chilostomella ovoidea* Reuss, as he does all of his representatives of the genus.

Hypotype.—Columbia University Micropaleontology Collection.

Family ORBULINIDAE Schultze, 1854

Genus GLOBIGERINA d'Orbigny, 1826

GLOBIGERINA BULLOIDES d'Orbigny

Plate 36, figure 26

Globigerina bulloides D'ORBIGNY, *1826*, Annales Sci. Nat., vol. 7, p. 277.

Test trochoid, four chambers to the last whorl; chambers inflated; sutures depressed; wall coarsely perforate or reticulate; aperture large, semicircular, opening into the umbilicus.

Diameter of the figured specimen, 0.43 mm.; thickness, 0.30 mm.

Many variations of the genus have been referred to this species of d'Orbigny, but it is here used *sensu stricto* as defined by Galloway and Wissler (1927).

Hypotype.—Columbia University Micropaleontology Collection.

GLOBIGERINA CONCINNA Reuss

Plate 36, figure 27

Globigerina concinna REUSS, *1850*, K. Akad. Wiss. Wien Denksch., vol. 1, p. 373, pl. 47, fig. 8.

Test trochoid, subcircular; chambers five in the last whorl, inflated, spherical; sutures depressed; wall coarsely perforate or reticulate; aperture large, semicircular, opening into the umbilicus.

Maximum diameter of the figured specimen, 0.45 mm.; maximum thickness, 0.32 mm.

This species is similar to *Globigerina bulloides* d'Orbigny, but is differentiated from that species by the greater number of chambers in the last whorl, which Reuss specifies as being five.

Hypotype.—Columbia University Micropaleontology Collection.

Genus GLOBIGERINOIDES Cushman, 1927

GLOBIGERINOIDES SACCULIFERA

(H. B. Brady)

Plate 36, figure 28

Globigerina sacculifera H. B. BRADY, *1877*, Geol. Mag., vol. 4, p. 535.

Globigerina sacculifera, H. B. BRADY, *1884*, Rep. Challenger Voy., Zool., vol. 9, p. 604, pl. 80, figs. 11–17.

Globigerinoides sacculifera CUSHMAN, *1927*, Scripps Inst. Oceanography Bull., vol. 1, no. 10, p. 173, no fig.

Test trochoid; chambers three and one-half to four and one-half in the last whorl, inflated, the last somewhat elongate; sutures depressed; wall coarsely perforate or reticulate; aperture large, semicircular, opening into the umbilicus, with secondary apertures opening into the umbilicus and the various chambers from the dorsal side.

Maximum diameter of figured specimen, 0.65 mm.; maximum thickness, 0.42 mm.

This species is rather sparsely represented in this material and seems to be an early form of the species. It corresponds closely to the specimens which Brady (1884) figures in the Challenger report as young, pelagic forms, which is quite understandable through simple application of the law of recapitulation. The young of a recent form of a species ought to exhibit the characteristics of a mature form from older beds, which appears to be the case here. Orthogenetically this species seems to be approaching a more digitate form.

Hypotype.—Columbia University Micropaleontology Collection.

GLOBIGERINOIDES TRILOBA (Reuss)

Plate 36, figures 29, 30

Globigerina triloba REUSS (not Cushman after Rhumbler), *1850*, K. Akad. Wiss., Wien Denksch, vol. 1, p. 374, pl. 47, fig. 11.

Test trochoid; chambers three to three and one-half in the last whorl, inflated; sutures depressed; wall coarsely perforate or

reticulate; aperture large, semicircular opening into umbilicus, with a supplementary aperture on the dorsal side.

Maximum diameter of figured specimen, 0.74 mm.; maximum thickness, 0.46 mm.

In his original description Reuss states,

> . . . zwei Mündungen zeigt, eine grosse auf der obern, eine kleine auf der untern Seite . . .

The specimens in this collection conform to Reuss's description and figures, and, since the secondary aperture is present, the species has been referred to the genus *Globigerinoides* Cushman (1927).

Hypotype.—Columbia University Micropaleontology Collection.

Genus PULLENIATINA Cushman, 1927
PULLENIATINA OBLIQUELOCULATA (Parker and Jones)
Plate 36, figure 31

Pullenia obliqueloculata PARKER and JONES, *1865*, Roy. Soc. London, Phil. Trans. vol. 155, p. 368, pl. 14, fig. 4.
Pulleniatina obliqueloculata CUSHMAN, *1927*, Cushman Lab. Foram. Research Contr., vol. 3, pt. 1, p. 90, pl. 19, figs. 5 a–c.

Test subglobular, coiled in an oblique rotaloid spire, last whorl partially evolute dorsally, showing one or two earlier chambers as in *Globigerina*, completely involute ventrally; chambers four or five in the last whorl, inflated; sutures depressed; test coarsely perforate; aperture is an elongate slit at the base of the last septal face, toward the ventral side of the test, with a slight upper lip.

Maximum height of figured specimen, 0.54 mm.; width 0.51 mm.; thickness, 0.48 mm.

Cushman considered the genus, of which he designated this species as the genotype, to be completely involute, and his figure, which is taken from Brady (1884), is so drawn. However, the type figure given by Parker and Jones shows the earlier chambers exposed, as do the specimens in the present collection.

Hypotype.—Columbia University Micropaleontology Collection.

Genus ORBULINA d'Orbigny, 1839
ORBULINA UNIVERSA d'Orbigny
Plate 36, figure 32

Orbulina universa D'ORBIGNY, *1839*, Hist. Phys. Pol. Nat. Cuba, vol. 2, Zool., p. 3, pl. 1, fig. 1.

Test spherical, only one chamber visible; wall with large and small pores; with or without a simple, rounded aperture.

Diameter of figured specimen, 0.53 mm.

This species is exceedingly abundant in this material and is characterized by the almost total absence of specimens possessing any definable aperture. It might be that this genus should be divided on the presence or absence of this simple apertural feature, as, if it be considered a gerontic form, as it usually is, the forms lacking the aperture would be senescent.

Hypotype.—Columbia University Micropaleontology Collection.

Family HETEROHELICIDAE Cushman, 1927
Genus BOLIVINA d'Orbigny, 1839
BOLIVINA DOTTIANNA Coryell and Mossman, n. sp.
Plate 36, figure 33

Test elongate, flattened, slightly tapered, initial end rather blunt in both microspheric and megaspheric forms; periphery carinate; chambers eight to 10 pairs, very slightly inflated, elongate; sutures limbate, slightly curved, meeting the periphery at an angle of about 45°; wall hyaline, coarsely perforate; aperture an elongate slit at the end of the last chamber, lying in the plane of the periphery, with a circumscribing lip.

Height of holotype, 0.98 mm.; width, 0.35 mm.; thickness, 0.07 mm.

Although this species is analogous with several others in various respects, it differs from all sufficiently to indicate that it represents a somewhat different line of development. It is characterized primarily by the limbate sutures and keel, and by the angle of the sutures with the periphery.

Holotype.—Columbia University Micopaleontology Collection.

BOLIVINA FORAMINATA (R. E. and K. C. Stewart)
Plate 36, figure 34

Bolivina seminuda var. *foraminata* R. E. and K. C. STEWART. *1930*, Jour. Paleontology, vol. 4, no. 1, p. 60, pl. 8, figs. 5 a, b.

Test elongate, fusiform, initial end bluntly pointed; chambers about 16 pairs, very slightly inflated, rather high; sutures slightly depressed; wall fairly coarsely perforate, the upper third of each chamber being less so,

EXPLANATION OF PLATE 36

FIGS. *1, 2—Robulus cushmani* var. *procedendus* Coryell and Mossman, n. var. *1*, Side view, ×35; *2*, Peripheral view, ×35. Holotype, Columbia University Micropaleontology Collection. (p. 234)

3, 4—Pullenia malkinae Coryell and Mossman, n. sp. *3*, Side view, ×30; *4*, Apertural view, ×30. Holotype, Columbia University Micropaleontology Collection. (p. 234)

5—Globorotalia menardii (d'Orbigny). Ventral view, ×30. Hypotype, Columbia University Micropaleontology Collection. (p. 234)

6—Valvulineria inaequalis (d'Orbigny). Ventral view, ×30. Hypotype, Columbia University Micropaleontology Collection. (p. 235)

7–9—Valvulineria inflata (d'Orbigny). *7*, Ventral view, ×30; *8*, Peripheral view, ×30; *9*, Dorsal view, ×30. Hypotype, Columbia University Micropaleontology Collection. (p. 235)

10–12—Valvulineria johnsoni Coryell and Mossman, n. sp. *10*, Ventral view, ×30; *11*, Peripheral view, ×30; *12*, Dorsal view, ×30. Holotype, Columbia University Micropaleontology Collection. (p. 235)

13–15—Valvulineria scintillans Coryell and Mossman, n. sp. *13*, Ventral view, ×30; *14*, Peripheral view, ×30; *15*, Dorsal view, ×30. Holotype, Columbia University Micropaleontology Collection. (p. 236)

16–18—Valvulineria scintillans var. *sinecarina* Coryell and Mossman, n. var. *16*, Ventral view, ×50; *17*, Peripheral view, ×50; *18*, Dorsal view, ×50. Holotype, Columbia University Micropaleontology Collection. (p. 236)

19—Epistomina bradyi Galloway and Wissler. Ventral view, ×35. Hypotype, Columbia University Micropaleontology Collection. (p. 236)

20—Gyroidina soldanii var. *multilocula* Coryell and Mossman, n. var. Ventral view, ×35. Holotype, Columbia University Micropaleontology Collection. (p. 237)

21, 22—Cibicides terryi Coryell and Mossman, n. sp. *21*, Ventral view, ×30; *22*, Dorsal view, ×30. Holotype, Columbia University Micropaleontology Collection. (p. 237)

23—Planulina ornata (d'Orbigny). Dorsal view, ×30. Hypotype, Columbia University Micropaleontology Collection. (p. 237)

24, 25—Chilostomella czjzeki Reuss. *24*, Side view, ×30; *25*, Dorsal view, ×30. Hypotype, Columbia University Micropaleontology Collection. (p. 237)

26—Globigerina bulloides d'Orbigny. Ventral view, ×45. Hypotype, Columbia University Micropaleontology Collection. (p. 238)

27—Globigerina concinna Reuss. Ventral view, ×45. Hypotype, Columbia University Micropaleontology Collection. (p. 238)

28—Globigerinoides sacculifera (H. B. Brady). Dorsal view, ×40. Hypotype, Columbia University Micropaleontology Collection. (p. 238)

29, 30—Globigerinoides triloba (Reuss). *29*, Ventral view, ×30; *30*, Dorsal view, ×30. Hypotype, Columbia University Micropaleontology Collection. (p. 238)

31—Pulleniatina obliqueloculata (Parker and Jones). Apertural view, ×30. Hypotype, Columbia University Micropaleontology Collection. (p. 239)

32—Orbulina universa d'Orbigny. ×30. Hypotype, Columbia University Micropaleontology Collection. (p. 239)

33—Bolivina dottianna Coryell and Mossman, n. sp. Microspheric form, ×30. Holotype, Columbia University Micropaleontology Collection. (p. 239)

34—Bolivina foraminata (R. E. and K. C. Stewart). Lateral view, ×30. Hypotype, Columbia University Micropaleontology Collections. (p. 239)

35–38—Bolivina interjuncta var. *bicostata* Cushman. *35*, Mature, microspheric form, ×30; *36*, Mature, megaspheric form, ×30; *37*, Young, microspheric form, ×30; *38*, Young, megaspheric form, ×30. Hypotype, Columbia University Micropaleontology Collection. (p. 241)

39—Bolivina pomposa Coryell and Mossman, n. sp. Side view, ×30. Holotype, Columbia University Micropaleontology Collection. (p. 241)

40—Bolivina pseudobeyrichia Cushman, Side view, ×30. Hypotype, Columbia University Micropaleontology Collection. (p. 242)

41—Bolivina sinuata var. *praevia* Coryell and Mossman, n. var. ×30. Holotype, Columbia University Micropaleontology Collection. (p. 242)

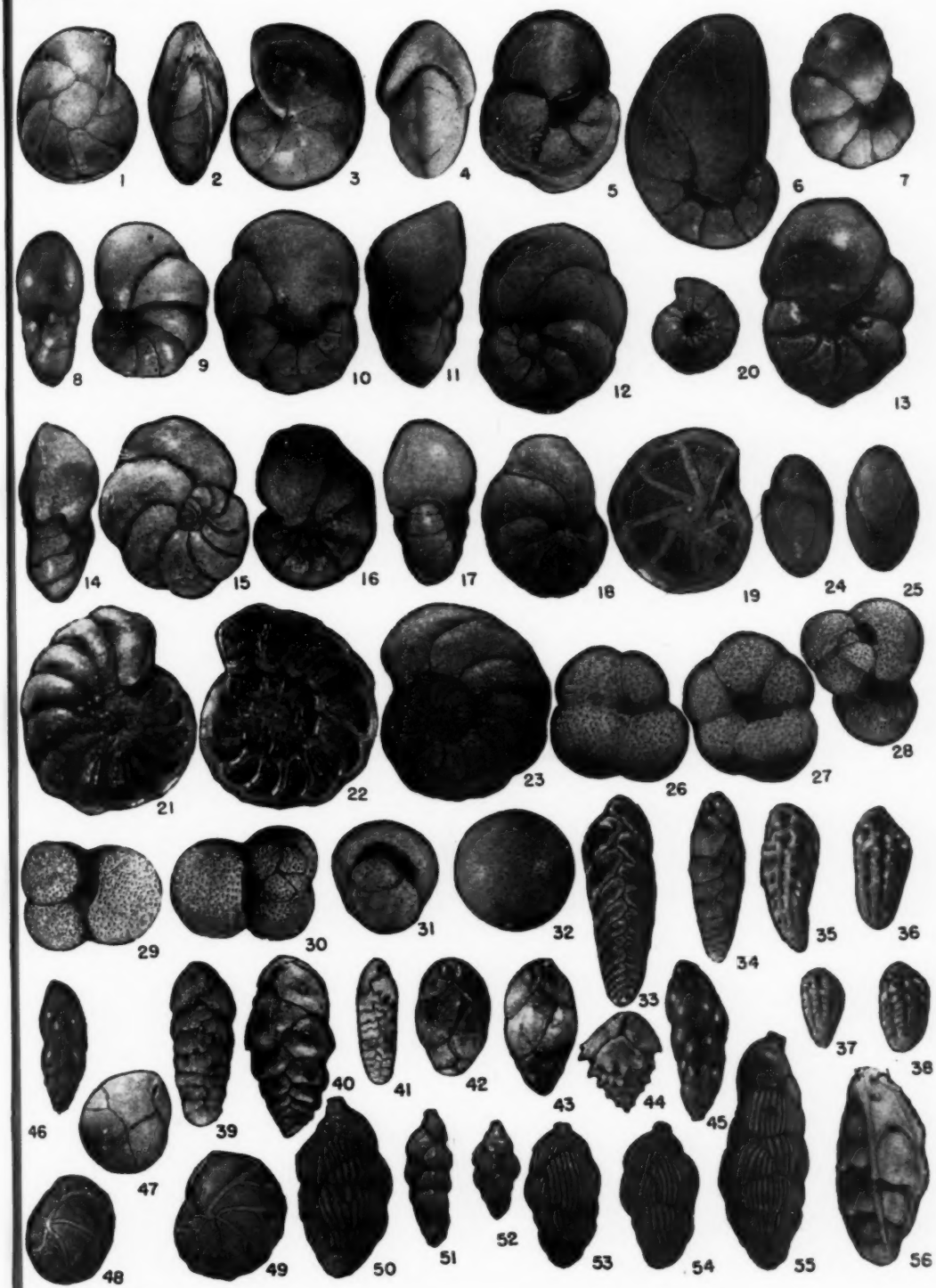
42—Bulimina affinis d'Orbigny. ×30. Hypotype, Columbia University Micropaleontology Collection. (p. 242)

43—Bulimina pupoides d'Orbigny. ×30. Hypotype, Columbia University Micropaleontology Collection. (p. 242)

44—Bulimina pagoda Cushman, ×35. Hypotype, Columbia University Micropaleontology Collection. (p. 242)

45—Buliminella inconstans (Egger). ×30. Hypotype, Columbia University Micropaleontology Collection. (p. 243)

(*Continued on page 241*)



Coryell and Mossman, Pliocene Foraminifera

UNIV. OF MICH.

and in the last one or two chambers the upper third of the wall being clear, hyaline, and smooth; aperture an elongate slit with a raised lip surrounding it.

Height of figured specimen, 0.82 mm.; width, 0.21 mm.; thickness, 0.23 mm.

The specimens here observed are much like those described by R. E. and K. C. Stewart from Ventura County, California, although they seem not to be quite so far advanced in the development of the smooth, glassy area on the upper part of the chambers. The extension of the range and the distinct variations seem to warrant that it be accorded specific rather than varietal rank, although there exists intimate ancestral relationship between this species and *Bolivina seminuda* of Stewart and Stewart. Their figured specimen is conspicuously wider near the apertual end than our specimen.

Hypotype.—Columbia University Micropaleontology Collection.

BOLIVINA INTERJUNCTA var. BICOSTATA Cushman
Plate 36, figures 35–38

Bolivina interjuncta var. *bicostata* CUSHMAN, *1926*, Cushman Lab. Foram. Research Contr., vol. 2, pt. 2, p. 42, no fig.
Bolivina interjuncta var. *bicostata*, CUSHMAN, *1937*, Cushman Lab. Foram. Research Spec. Publ., no. 9, p. 116, pl. 22, fig. 23.

Test elongate, tapering, inital end bluntly pointed in megaspheric form, pointed in microspheric, test compressed, provided with a very subdued bifurcated marginal keel, and laterally ornamented with four, longitudinal costae not bifurcating or anastomosing, with the two medial ones the most prominent; chambers numerous, narrow; sutures distinct, slightly raised; wall hyaline, finely perforate.

Dimensions of figured specimens: Mature microspheric form, height, 0.71 mm.; width, 0.28 mm.; thickness, 0.16 mm.: Mature megaspheric form, height, 0.57 mm.; width, 0.29 mm.; thickness, 0.16 mm.: Young microspheric form, height, 0.40 mm.; width, 0.21 mm.; thickness, 0.09 mm.: Young megaspheric form, height, 0.44 mm.; width, 0.23 mm.; thickness, 0.11 mm.

This variety, as represented in this collection, seems to be a slightly more advanced stage between the *Bolivina interjuncta* var. *bicostata* Cushman of California and the type of the species, but still definitely belongs to the varietial form, which is apparently ancestral to the type.

Hypotype.—Columbia University Micropaleontology Collection.

BOLIVINA POMPOSA
Coryell and Mossman, n. sp.
Plate 36, figure 39

Test elongate, slightly tapering, oval in cross section, initial end bluntly rounded; chambers six to eight pairs, becoming progressively more inflated toward the apertural end so that the last chamber on each side overhangs at the periphery; sutures depressed, somewhat obscure in the early

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46—*Buliminella inconstans* var. *basispinata* R. E. and K. C. Stewart, 30. Hypotype, Columbia University Micropaleontology Collection. (p. 243)
47—*Cassidulina californica* Cushman and Hughs. ×45. Hypotype, Columbia University Micropaleontology Collection. (p. 243)
48—*Cassidulina cushmani* R. E. and K. C. Stewart. ×65. Hypotype, Columbia University Micropaleontology Collection. (p. 243)
49—*Cassidulina pulchella* d'Orbigny. ×30. Hypotype, Columbia University Micropaleontology Collection. (p. 244)
50—*Uvigerina gallowayi* Coryell and Mossman, n. sp. ×35. Holotype, Columbia University Micropaleontology Collection. (p. 244)
51—*Uvigerina buricensis* Coryell and Mossman, n. sp. ×30. Holotype, Columbia University University Micropaleontology Collection. (p. 244)
52—*Uvigerina raricosta* d'Orbigny. ×35. Hypotype, Columbia University Micropaleontology Collection. (p. 244)
53, 54—*Uvigerina striata* d'Orbigny. Two different specimens. ×30. Hypotype, Columbia University Micropaleontology Collection. (p. 245)
55—*Uvigerinata striata* var. *attenuata* Coryell and Mossman, n. var. ×30. Holotype, Columbia University Micropaleontology Collection. (p. 245)
56—*Angulogerina carinata* Cushman. ×30. Hypotype, Columbia University Micropaleontology Collection. (p. 245)

part; wall coarsely perforate, in the earlier half of the test slightly granular and ornamented with a few indistinct costae; aperture terminal, elongate, parallel to the width, with a raised circumscribed lip.

Height of holotype, 0.79 mm.; width, 0.34 mm.; thickness, 0.22 mm.

This species is unique in its overinflated chambers and restricted ornamentation. It is very abundant.

Holotype.—Columbia University Micropaleontology Collection.

BOLIVINA PSEUDOBEYRICHIA Cushman
Plate 36, figure 40

Bolivinia beyrichia var. *slata* CUSHMAN (not Seguenza), *1911*, U. S. Nat. Mus. Bull. 71, pt. 2, p. 35, text figs. 57 a, b.

Bolivina pseudobeyrichia CUSHMAN, *1926*, Cushman Lab. Foram. Research, vol. 2, pt. 2, p. 45, no fig.

Test compressed, broad, expanding; periphery keeled; chambers rapidly increasing in width, slightly inflated, pointed at peripheral edge; sutures depressed; wall hyaline, perforate; aperture elongate, in the peripheral plane, with a raised lip.

Height of figured specimen, 0.85 mm.; width, 0.44 mm.; thickness, 0.12 mm.

This species, while it is definitely different from *Bolivina alata* (Seguenza) both in physical characteristics and in range, is, in so many ways, similar to that species that it may well represent a case of parallel development in distinctly different portions of the globe.

Hypotype.—Columbia University Micropaleontology Collection.

BOLIVINA SINUATA var. PRAEVIA
Coryell and Mossman, n. var.
Plate 36, figure 41

Test elongate, slightly tapering, compressed oval, usually somewhat twisted; chambers slightly inflated; sutures curved in early part, strongly lobate in later part; wall perforate; aperture an elongate slit on the inner margin of the last chamber, with a raised lip.

Height of holotype, 0.60 mm.; width, 0.20 mm.; thickness, 0.11 mm.

This variety differs from the typical in the straighter form of the sutures in the early part of the test, the absence of the costae, and the more oval outline in cross section. It is close to *Bolivina sinuata* var. *alisoensis* Cushman and Adams (1935), but the latter has the sutures sinuate throughout. It is apparently an ancestral variety of the species.

Holotype.—Columbia University Micropaleontology Collection.

Family BULIMINIDAE Jones, 1876
Genus BULIMINA d'Orbigny, 1826

BULIMINA AFFINIS d'Orbigny
Plate 36, figure 42

Bulimina affinis D'ORBIGNY, *1839*, Hist. Phys. Pol. Nat. Cuba, vol. 2, Zool., p. 105, pl. 2, figs. 25, 26.

Test broadly fusiform, bluntly pointed at initial end, rapidly expanding, consisting of about four whorls; chambers globular, embracing; sutures depressed; wall hyaline, smooth; aperture virguline, in a slight depression in the last septal face.

Height of figured specimen, 0.56 mm.; maximum diameter, 0.31 mm.

Hypotype.—Columbia University Micropaleontology Collection.

BULIMINA PUPOIDES d'Orbigny
Plate 36, figure 43

Bulimina pupoides D'ORBIGNY, *1846*, Foram. Foss. Bass. Tert. Vienne, p. 185, pl. 11, figs. 11, 12.

Test of about four whorls, fusiform, bluntly pointed at initial end, fairly rapidly expanding, chambers globular, embracing; sutures depressed; wall hyaline, smooth; aperture virguline, in a slight depression in the last septal face.

Height of figured specimen, 0.61 mm.; maximum diameter, 0.35 mm.

This species differs from *Bulimina affinis* d'Orbigny in having the chambers more closely appressed and slightly more numerous, and being a little more elongate in form.

Hypotype.—Columbia University Micropaleontology Collection.

BULIMINA PAGODA Cushman
Plate 36, figure 44

Bulimina pagoda CUSHMAN, *1927*, Scripps Inst. Oceanography Bull., vol. 1, no. 10, p. 152, pl. 2, fig. 16.

Test of about four whorls, high-spired, tapering, triserial, broadest at apertural end; chambers closely appressed, strongly over-

hanging, with a number of stout, outwardly projecting and downwardly curving spines attached to the outer, lower edge of each chamber; wall hyaline, smooth, except for the spines; aperture a long comma-shaped slit extending from the last suture partially across the last septal face, in a shallow depression.

Height of figured specimen, 0.44 mm.; maximum diameter, 0.36 mm.

Cushman reports this species from one station only, off Panama, and the Pliocene specimens of this collection are practically identical, which would seem to indicate that the species is a provincial one.

Holotype.—Columbia University Micropaleontology Collection.

Genus BULIMINELLA Cushman, 1911
BULIMINELLA INCONSTANS (Egger)
Plate 36, figure 45

Bulimina inconstans EGGER, *1857*, Neues Jahrb. p. 283, pl. 12, figs. 8, 9.
Bulimina pupoides WILLIAMSON (not d'Orbigny), *1858*, Rec. Foram. Gt. Brit., p. 61, pl. 5, figs. 124, 125.

Test elongate, tapering, thickest in later part; chambers inflated, coiled in a spiral about the axis, usually four to a whorl; sutures distinct, depressed; wall hyaline, smooth, very finely perforate; aperture vertical, extending from the last suture up into the last septal face and surrounded by a raised rim.

Height of figured specimen, 0.69 mm.; diameter, 0.26 mm.

This specimen is very close to that figured by Egger, which appears to be a valid species, and not, as Cushman states (1937), a synonym of *Bulimina elongata* d'Orbigny.

Hypotype.—Columbia University Micropaleontology Collection.

BULIMINELLA INCONSTANS var BASISPINATA
(R. E. and K. C. Stewart)
Plate 36, figure 46

Buliminella curta var. *basispinata* R. E. and K. C. STEWART, *1930*, Jour. Paleontology, vol. 4, no. 1, p. 63, pl. 8, fig. 6.

Test elongate, tapering, thickest in later part, chambers inflated, coiled in a spiral about the axis, usually four to a whorl; sutures distinct, depressed; wall hyaline, smooth in later part but covered with numerous small but distinct spines in early portion, very finely perforate; aperture vertical, curved or comma-shaped, extending from the last suture up into the last septal face and surrounded by a raised rim.

Height of figured specimen, 0.57 mm.; diameter, 0.21 mm.

This specimen is nearly identical with *Buliminella inconstans* (Egger) but with the addition of the spines of the earlier portion. R. E. and K. C. Stewart believed it to be a variety of *Buliminella curta* (Cushman), but recognized that it differed considerably from that species. Its very close similarity to *B. inconstans* (Egger) and the occurrence with it in the same formation seems adequate evidence for its being referred to this species as a variety.

Hypotype.—Columbia University Micropaleontology Collection.

Family CASSIDULINIDAE d'Orbigny, 1839
Genus CASSIDULINA d'Orbigny, 1826
CASSIDULINA CALIFORNICA
Cushman and Hughes
Plate 36, figure 47

Cassidulina californica CUSHMAN and HUGHES, *1925*, Cushman Lab. Foram. Research Contr., vol. 1, p. 12, pl. 2, figs. 1 a–c.

Test subcircular in side view, nearly oval in peripheral view, with slides parallel; chambers five pairs in the last whorl, slightly inflated and completely embracing, the last protruding; sutures fairly distinct, nearly flush; wall hyaline, smooth, aperture parallel to one side of the plane of coiling, with a platelike tooth.

Diameter of figured specimen, 0.46 mm.; thickness, 0.23 mm.

This appears to be a very common and fairly long ranging species along the American coast of the Pacific from the late Tertiary to the Recent. It is very abundant on the Burica Peninsula.

Hypotype.—Columbia University Micropaleontology Collection.

CASSIDULINA CUSHMANI R. E.
and K. C. Stewart
Plate 36, figure 48

Cassidulina cushmani R. E. and K. C. STEWART, *1930*, Jour. Paleontology, vol. 4, no. 1, p. 71, pl. 9, figs. 5 a, b.

Test compressed, subcircular in side view;

periphery acute, slightly carinate; chambers four pairs in the last whorl, completely embracing; sutures distinct, strongly curved, flush; test hyaline, smooth; aperture an elongate slit parallel to the curve of the last chamber, usually with a tooth.

Diameter of figured specimen, 0.25 mm.; thickness, 0.12 mm.

This material has yielded specimens that appear to be identical with those which Stewart and Stewart found in the Pliocene of Ventura County, California. They state in their paper that the chambers of the opposite series show through in the outer portion of the test. While this characteristic was observed in the Panama specimens, it should be noted that the least opacity of preservation would render this character unobservable.

Hypotype.—Columbia University Micropaleontology Collection.

CASSIDULINA PULCHELLA d'Orbigny
Plate 36, figure 49

Cassidulina pulchella D'ORBIGNY, *1839*, Voy. Amer. Merid., vol. 5, pt. 5, p. 57, pl. 8, figs. 1–3.

Test subcircular in side view, periphery slightly carinate, coiled biserially and completely involute; chambers seven on each side in the last whorl, not inflated, meeting the periphery in such a way as to form a slight hook on the side next to the previous chamber; sutures flush, very slightly limbate, meeting the periphery in a re-entrant just beneath the projecting corner of the chamber; wall hyaline, smooth; aperture a comma-shaped slit parallel to, but not in the plane of coiling, usually with a slight platelike tooth.

Diameter of figured specimen, 0.57 mm.; thickness, 0.24 mm.

The specimens in this collection are seemingly identical with the original ones of d'Orbigny, fitting his description and figures nicely. The presence of the hooklike projections on the ends of the chambers seems to be of distinct importance, but if the peripheral keel be developed at all strongly, this feature may be so subdued as to be practically unnoticeable.

Hypotype.—Columbia University Micropaleontology Collection.

Family UVIGERINIDAE Galloway and Wissler, 1927

Genus UVIGERINA d'Orbigny, 1826

UVIGERINA GALLOWAYI
Coryell and Mossman, n. sp.
Plate 36, figure 50

Test fusiform, about four whorls; chambers numerous, appressed; sutures distinct, depressed; wall with about 12 vertical, somewhat hispid or serrated costae; aperture terminal, at the end of a short neck, with a phialine lip. This species is most prominently characterized by the serrated or hispid costae.

Height of figured specimen, 0.76 mm.; diameter, 0.42 mm.

Holotype.—Columbia University Micropaleontology Collection.

UVIGERINA BURICENSIS
Coryell and Mossman, n. sp.
Plate 36, figure 51

Test elongate, fusiform, about five whorls; chambers globular, becoming irregularly added in later part; sutures distinct, depressed; wall hyaline, smooth, ornamented by four to six fine, widely spaced, vertical costae on each chamber, which project from the lower side of the chamber to form inconspicuous spines; aperture terminal, at the end of a short neck, with a phialine lip.

Length of holotype, 0.60 mm.; maximum diameter, 0.42 mm.

This species is most nearly like *Uvigerina raricosta* d'Orbigny, from which it may be evolved. However, it differs from that species in the more elongate form, the greater number of costae, and their spinose terminations.

Holotype.—Columbia University Micropaleontology Collection.

UVIGERINA RARICOSTA d'Orbigny
Plate 36, figure 52

Uvigerina raricosta D'ORBIGNY, *1839*, Voy. Amer. Merid., vol. 5, pt. 5, p. 53, pl. 7, fig. 15.

Test fusiform, of about four whorls; chambers few, globular; sutures distinct, depressed; wall hyaline, smooth except for two or three short, thin, vertical costae on each chamber; aperture terminal, at the end of a short neck, usually with a phialine lip.

Height of figured specimen, 0.41 mm.; diameter, 0.21 mm.

This species is small and relatively smooth, the costae being on the whole less prominent than as figured by d'Orbigny in his South American paper, and not always extending completely across the individual chamber.

Hypotype.—Columbia University Micropaleontology Collection.

UVIGERINA STRIATA d'Orbigny
Plate 36, figures 53–54

Uvigerina striata D'ORBIGNY (not Costa, 1856) *1839*, Voy. Amer. Merid., vol. 5, pt. 5, p. 53, pl. 7, fig. 16.

Test fusiform, irregularly triserial, comprising about four whorls; chambers few, globular; sutures distinct, depressed; wall with 10 to 14 vertical costae, interrupted and occasionally bifurcating, not continuous across sutures; aperture terminal, at the end of a short neck, with a phialine lip.

Height of figured specimen, 0.65 mm.; diameter, 0.34 mm.

This species is very abundant in the Charco Azul material.

Hypotype.—Columbia University Micropaleontology Collection.

UVIGERINA STRIATA var. ATTENUATA
Coryell and Mossman, n. var.
Plate 36, figure 55

Test elongate, fusiform, triserial in early portion with two or three chambers added irregularly to later part, about four whorls in triserial portion; chambers few, globular; sutures distinct, depressed; wall with 10 to 14 vertical costae, interrupted and occasional bifurcating, not continuous across sutures; aperture terminal, at the end of a short neck, with a phialine lip.

Height of holotype, 1.05 mm.; diameter, 0.39 mm.

This variety represents a more gerontic stage of the species in the addition of the new irregular chambers, which serve to distinguish it from the type of the species.

Holotype.—Columbia University Micropaleontology Collection.

Genus ANGULOGERINA Cushman 1927
ANGULOGERINA CARINATA Cushman
Plate 36, figure 56

Uvigerina angulosa H. B. BRADY (not Williamson), *1884*, Rep. Voy. Challenger, Zool., vol. 9, pl. 74, fig. 18.

Angulogerina carinata CUSHMAN, *1927*, Scripps Inst. Oceanography Bull., vol. 1, no. 10, p. 159, pl. 4, fig. 3.

Test elongate, triangular in section, sides flattened, angles with sharp carinae with fine radial tubules; chambers few; sutures depressed; wall calcareous, hyaline; aperture terminal, at the end of a short neck, with a phialine lip.

Height of figured specimen, 0.94 mm.; width, 0.47 mm.

The close affinity of the Charco Azul specimens to the Scripps specimens of Cushman is shown by the presence of the radial tubules in the carinae.

Hypotype.—Columbia University Micropaleontology Collection.

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PALEONTOLOGICAL NOTES

PARALLELODON, GRAMMATODON, AND BEUSHAUSENIA (=COSMETODON, NEW NAME)

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In a study of the Jurassic Arcidae, Arkell (1930, pp. 297–310) has shown that the species of *Parallelodon*, *Grammatodon*, and *Beushausenia* are sufficiently close to be grouped in one genus and he proposes to combine the three as subgenera in the genus *Parallelodon*. The range of the genus as defined appears to be Silurian to Cretaceous. In the matter of nomenclature, however, Arkell does not abide by the rules and has introduced confusion into an already chaotic literature. It is the purpose of this note to show the correct nomenclature for these fossils.

The earliest name applied to species of the group of arcids under consideration is *Macrodon* (Lycett, ms.) Buckman, 1845, (Murchison 1845, p. 98) with genotype species *M. rugosus* Buckman. This name had already been used by Schinz in 1822 for a genus of fish (Cuvier, Das Thierreich, vol. 2, p. 482) and by Mueller in 1842, also for a genus of fish (Ber. Verh. preuss. Akad. Wiss., p. 178). Meek and Worthen (1866, p. 51) noted the homonym with Mueller's generic name and suggested that *Macrodon* Buckman be replaced by *Parallelodon* Meek and Worthen, 1866, new name. The genotype, by rule, is that of the genus the name of which is replaced, that is, *Macrodon rugosus* Buckman.

Beushausen (1895, p. 37) described species of *Macrodon*, but in most places in his work he spells the name "*Macrodus*." He points out that his species differ from *Macrodon hirsonensis* d'Archiac, which he cites as the genotype. This citation arose from the mistaken idea of some authors that *M. rugosus* and *M. hirsonensis* are identical. Arkell, and apparently Tornquist and Clarke (1907, p. 207) have assumed that Beushausen was creating a new generic name to replace *Macrodon*. Beushausen states, however, that he is unable to verify the previous use of the name *Macrodon* and in two separate places in his generic discussion he says that he does not propose to set up a new genus.

Cossmann (1897, p. 93), in reviewing Beushausen's work, correctly recognized *Macrodus* Beushausen as a misspelling of *Macrodon* and following Fischer in his statement that *Macrodon* differs from *Parallelodon* suggested the name *Beushausenia*, new name, for *Macrodon* "Lycett." Since Arkell has interpreted Cossmann's name as a valid genus it is illuminating to quote Cossmann. His generic description reads (1897, p. 93):

> A propos du genre *Macrodon* Lycett (que l'auteur écrit *Macrodus*), M. Beushausen signale un double emploi avec *Macrodon* Mueller 1842 (Pisces); si, comme l'indique Fischer dans son Manuel, ce genre se distingue de *Parallelodon* Meek and Worthen, pars ses dents anterieures obliquées, et s'il faut reellement l'admettre comme section de *Parallelodon*, il y aurait lieu de liu donner une nouvelle denomination pur corriger ce double emploi: en conséquence, je propose *Beushausenia* pour le meme type *Cucullaea hirsonensis* d'Arch.

Arkell states (1930, p. 303)

> A name already exists for it, *Beushausenia* Cossmann, suggested as a substitute for *Macrodus* Beushausen, which in turn was intended to replace *Macrodon* Buckman but was not sufficiently different from the original to be valid.

As has been shown above, Beushausen did not propose a new generic name and Cossmann did not assume that he did. Cossmann did not reject *Macrodus* Beushausen for any reason, and in any case a name can not be rejected for the reason attributed to Cossmann by Arkell (International Rules of Zoological Nomenclature, Article 36). Furthermore, even should Beushausen's misspelling be considered a new generic name, it is invalid as the name *Macrodus* was used by Gray in 1865 for a genus of Mammalia (Proc. Zool. Soc. London for 1864, p. 536). It is clear that Cossmann was giving a replacement name to *Macrodon* Lycett (which

is *Macrodon* Buckman) and as such, the genus must take the genotype of the original, that is, *Macrodon rugosus* Buckman, and *Beushausenia* then becomes an exact objective synonym of *Parallelodon*. The fact that Cossmann followed Beushausen in citing *Cucullaea hirsonensis* d'Archiac as type does not distinguish the new genus since such a procedure is not valid, and in any case *C. hirsonensis* is cited as type under the assumption that *Macrodon rugosus* is a synonym of that name.

Arkell has shown that there is a group of species typified by *Cucullaea hirsonensis* d'Archiac and that *Macrodon rugosus* is a different form. Morris and Lycett (1853, p. 50) state that *M. rugosus* appears to be another species than *M. hirsonensis* (Arkell states that they believed the two to be the same), but in the supplement to their monograph (1863, p. 113) they describe *M. hirsonensis rugosa* without identifying the authorship. Arkell (1930, p. 298) shows that the form illustrated by Morris and Lycett as *M. hirsonensis* is indistinguishable from *M. rugosus*, and that the species is subgenerically distinct from *M. hirsonensis* d'Archiac. This stock is still without a name.

The writer here proposes the new subgeneric name, *Cosmetodon* Branson (etymology — Greek — *cosmetos*, well-arranged, and *odous*, tooth).

The subgeneric characters of *Cosmetodon* are as follows: shell elongate, subquadrangular, greatest length below midheight, greatest height near posterior, umbones near anterior. Surface marked by numerous growth lines and by radii only slightly more prominent than the average growth line. A distinct and abruptly bordered sulcus extends from the surface of the umbo vertically to the ventral margin. The hinge plate is wide and massive, the three or four posterior teeth are linear, originate on the ventral edge of the hinge plate beneath the umbo, extend obliquely upward and backward and curve into parallelism with the hinge throughout most of their length, but diverge ventrally from the hinge near their posterior terminations near the end of the hinge plate. The six or seven short anterior teeth are directed upward and forward from the ventral edge of the anterior portion of the hinge plate.

Cosmetodon differs from *Grammatodon* in that the shell is more elongate, the beaks are farther forward, and the posterior teeth are parallel to the hinge for a greater distance and even diverge ventrally from the hinge. Shells of *Cosmetodon* differ from those of the subgenus *Parallelodon* in that the anterior and posterior corners of the hinge are never alate and the greatest length is below midheight rather than along the hinge. Externally they bear finer radii and have well-developed sulci.

In order to avoid even the semblance of a replacement name and to fix the name to available and well-illustrated specimens *Beushausenia keyserlingi* (Orbigny), 1850, illustrated by Arkell from Borissjack (Arkell, 1930, pl. 14, fig. 9, 9a, 10) is designated genotype. D'Orbigny (1850, p. 369) gave the name *Arca keyserlingii* for *Arca elongata* Keyserling, 1846, preoccupied, and the new combination is by Arkell. The species occurs in the Oxfordian of Russia and elsewhere.

As stated above, the writer accepts Arkell's arrangement of the three groups of arcids into one genus. Arkell places the three subgenera *Parallelodon*, *Grammatodon*, and *Beushausenia* (= *Cosmetodon*) under the generic name *Parallelodon*. He justifies this procedure as follows (Arkell 1930, p. 306)

> *Grammatodon* . . . has priority by six years over *Parallelodon* as a name. *Parallelodon* has priority by fifteen years over *Grammatodon* as a genus. . . . I favor the retention of *Parallelodon* as the generic name.

This procedure is directly contrary to Article 28 of the International Rules of Zoological Nomenclature, which reads in part

> A genus formed by the union of two or more genera takes the oldest valid generic or subgeneric name of its components.

Grammatodon was described by Meek and Hayden in 1860 (p. 419) and has clear priority.

In summary, the arcid subgenera treated by Arkell must be grouped in the genus *Grammatodon* Meek and Hayden, genotype *Arca inornata* Meek and Hayden, with subgenera *Grammatodon*, *Parallelodon* Meek and Worthen, subgenotype *Macrodon rugosus* Buckman, and *Cosmetodon* Branson, subgenotype *Arca keyserlingi* d'Orbigny. The

name *Parallelodon* in becoming the name of a subgenus is no longer available as root of the family name, which accordingly becomes Grammatodontidae.

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SPIRIFER OCCIDENTALIS GIRTY

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This species was originally described and illustrated by Swallow in 1860 under the name *S. boonensis*.[1] The publication of U.S.G.S. Prof. Paper 152 by Girty[2] introduced *S. boonensis* var. *occidentalis*. It was illustrated again with additional notes by Dunbar and Condra, in Nebraska Geological Survey Bulletin 5, second series, pages 322–325, Plate 41, figures 12–16, and given specific rank. The specimens were exfoliated and partly weathered, with hinge tips broken or damaged. The details for con-

FIG. 1—Complete ventral valve, ×2, of *Spirifer occidentalis* Girty, from the Atoka formation, northeastern Oklahoma.

[1] St. Louis Acad. Sci. Trans. vol. 1, 1860. p. 646.
[2] 1927, p. 433, Pl. 27, figs. 28–31.

sideration are stated in a quotation from Dunbar and Condra:

> A transverse species of moderate size commonly attaining a width of 3 or 3.5 cm. and a length of 2.5 cm. or more. The greatest width is at or very near the hinge line and the cardinal extremities are approximately at right angles or moderately extended or a little rounded.[3]

The variable form appears to be the result of damage rather than variation of original characters. At the Okay, Oklahoma, locality which yielded many of Dunbar and Condra's specimens, it is common to find all the varieties of form mentioned in the above descriptions, but a close examination shows that they are damaged by crushing and by breaking of tips. One large ventral valve with both hinge tips measures 5.5 cm. in width, with tips of 7 and 8 mm., and 2.4 cm. in length. As it is still in the matrix the anterior is possibly not entirely uncovered. Several smaller shells show tips of 4 or 5 mm. Other specimens show one tip intact or somewhat damaged and one missing or buried in the matrix.

The accompanying illustration of a large shell with mucronate extensions is thought to be more representative of the normal form of this species than the figures in the Nebraska report by Dunbar and Condra (Plate 41, figs. 12–16). Thus the greatest width in the undamaged form is along the hinge line, which is terminated by mucronate tips.

In Dunbar and Condra's paragraph discussing "Occurrence" the location is given as "Rex Bridge, over Grand River, Northeast of Muskogee, Oklahoma, where the specimen is associated with *Marginifera muricatina*." The location is not correctly stated. It is on the Verdigris River at the town of Okay, formerly known as Rex Bridge, and shown as Correta on the Muskogee topographic sheet of the U. S. Geological Survey.

The horizon is the Webber's Falls shale of the Atoka formation. The fossils occur in limestone lenses from two to four inches thick.

The illustrated specimen is in the collection of the Paleontology Department of the University of Oklahoma.

[3] Pp. 322–323.

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ERRONEOUS EMENDATION OF GENERIC NAMES

RAYMOND C. MOORE, J. MARVIN WELLER, AND J. BROOKES KNIGHT

ABSTRACT—The commonly accepted orthography for many generic names of fossils differs from that which was published originally. Also, some generic names have two or more variant spellings that are currently employed by paleontologists. This paper undertakes to analyze and interpret portions of the International Rules of Zoological Nomenclature and published Opinions of the International Commission that bear on the emendation of generic names. Several examples of changes in the spelling of names of genera are considered and the conclusion is reached that only in very clear-cut and exceptional cases, as provided in the Rules, is any modification of the original published form of a generic name justified. Stability and uniformity in nomenclature is a primary objective of the Rules, and this calls for strict adherence to rather narrowly interpreted injunctions of the Rules pertaining to emendation of names.

INTRODUCTION

Generic names that differ in spelling from their original published form are not uncommon in paleontologic literature and they offer a problem that is often bothersome to the careful student. Which among variant spellings of the name of a specified genus is the correct one? Under what circumstances is emendation of a generic name proper and under what conditions is it erroneous? The correct answers to these questions are none too obvious, and judging by

the published works of many authors, including ourselves, such questions of nomenclature frequently have been ignored or disposed of by misguided choice.

The commonly accepted orthography for some generic names represents an emendation of their original form that is not only unsupported by the International Rules of Zoological Nomenclature (Congrès Intern. Zool., 1914; Schenk and McMasters, 1936, pp. 27–56) but is actually in conflict with them. Mostly, the adoption of such emended spelling has resulted from lack of understanding rather than from lack of interest in correct usage or from carelessness. It may be claimed that the Rules are not completely lucid and unequivocal on the subject of emending generic names, inasmuch as they have been differently interpreted and applied by different workers. Knight (1941) has recently used the term "classicists" for the group holding that improperly transliterated generic names are emendable according to certain classical orthographic usage and he has designated "legalists" those who believe that strict procedure under the Rules permits no such changes of spelling. Both of these groups embrace individuals who might be designated loosely as "agnostics" because they have no independent judgments and unquestioningly follow in sheeplike manner the usage adopted by others. Perhaps we should recognize also small groups of "aboriginals," who suffer from lack of tutoring, and "anarchists," who object to being bothered by rules. It is reasonable to think, however, that all these groups can be brought together by persuading workers to recognize stability and uniformity in biologic nomenclature as supremely needful. It is important to seek the principles governing emendation of names, as provided by the International Rules, and to learn how they must be applied in order to achieve uniformity and stability. We propose to discuss pertinent sections of the Rules and Opinions bearing on these matters and to give attention to a few representative cases of changes in the spelling of generic names among fossils.

THE OBJECTIVES OF STABILITY AND UNIFORMITY IN ZOOLOGICAL NOMENCLATURE

Almost axiomatic is the proposition that stability in zoological nomenclature and uniformity of procedure in using zoological names are prime requisites of paleontology, as of other branches of biologic science. It is well to emphasize this strongly and in as many ways as possible. In proportion to lack of stability and uniformity, confusion and obscurity are bound to exist. If generic names and other classificatory designations can be written in various ways by different workers on the basis of suitability, euphony, personal whim or miscellaneous other grounds, ignoring matters of priority, synonymy, homonymy and the like, the obvious result is chaos. Many provisions of the International Rules are clearly directed toward avoidance of instability and disuniformity. Quotation of parts of a few of the articles will serve to remind the reader, if that is necessary.

> The valid name of a genus or species can be only that name under which it was first designated . . . . . (Art 25).
>
> The Law of Priority obtains and consequently the oldest available name is retained . . (Art. 27)
>
> A genus formed by the union of two or more genera or subgenera takes the oldest valid generic or subgeneric names of its components . . . . . (Art. 28)
>
> If a genus is divided . . . its valid name must be retained for one of the restricted genera . . . . . (Art. 29)
>
> A generic or a specific name, once published, cannot be rejected, even by its author, because of inappropriateness . . . . . (Art. 32)
>
> A generic name is to be rejected as a homonyn when it has previously been used for some other genus of animals . . . . . (Art. 34)

Formulation of generic names, according to the Rules, is simple. They "must consist of a single word, simple or compound, written with a capital initial letter" (Art. 8), they must be "either Latin or Latinized, or considered and treated as such in case they are not of classic origin" (Art. 3), and "in forming names derived from languages in which the Latin alphabet is used, the exact original spelling, including diacritic marks, is to be retained" (Art. 20). Examples are given and the Rules are accompanied by numerous Recommendations that "should be" or "may be" followed. The Recommendations are patently not a part of the regulations that are given as Articles of the Rules. This is shown by their designation as "Recommendations," by phraseology that

repeatedly is employed in them, and by various Opinions that have been given by the Commission. They are advisory and permissive, not mandatory.

The only provision in the Rules for emendation of a published generic name is contained in Article 19, which states that

> The original orthography of a name is to be preserved unless an error of transcription, a *lapsus calami*, or a typographical error is evident.....(Art. 19)

The intent and the limits of meaning of this provision of the Rules will be discussed at some length in following parts of this paper. It seems desirable here merely to point out that the spirit and letter of the Rules are very definitely directed toward stability and uniformity of nomenclature. Minimum conditions are given for alteration of names, once they have been introduced in the literature. Assuming that all will agree to the statement that

> (a) The objective of the Rules is to promote stability and uniformity in zoological nomenclature,

it is likely that agreement equally will be given to the proposition that

> (b) The objective of stability and uniformity in zoological nomenclature may be attained best by rigid adherence to the Rules without granting rights to more or less widely varying individualistic interpretations.

It is evident that to the extent "classicists" deviate rightly or wrongly from "legalists" or other groups there is lack of stability and uniformity.

SIGNIFICANCE OF THE INTERNATIONAL RULES

All technical questions of zoological nomenclature, excluding matters calling for application of purely zoological criteria, must be decided on the basis of the International Rules. Portions of the Rules that are applicable to the emendation of generic names are listed and discussed briefly in the following numbered sections.

(1) *Strict application of Rules.*—The International Rules of Zoological Nomenclature are intended to be applied strictly. This is indicated clearly by the first sentence of the Resolution providing for the "Suspension of Rules in Certain Cases," which states that the Commission is empowered to suspend the Rules "where in its judgment the *strict* application of the Rules will clearly result in greater confusion than uniformity, . . . " (our italics).

The desirability and wisdom of strict application of the Rules seem self-evident, if it is granted that stability and uniformity of nomenclature are objectives having utmost value to zoological science. Loose application of the Rules and wide latitude of interpretation by individual workers certainly do not conduce to these objectives.

(2) *Recommendations accompanying Rules not mandatory.*—Use of the words "should" and "may" and expressions such as "it is advisable" and "it is recommended" in the Recommendations and Appendix, as contrasted with "must," "is always," "are not acceptable," etc. in Articles of the Rules is significant. Because they are to be applied strictly, the Rules are expressed mostly in positive statements. The Recommendations and Appendix are obviously not integral parts of the Rules and consequently they are expressed less positively. The Recommendations (as the name implies) and the Appendix are intended as suggestions pointing the way toward preferable practice. One of their primary purposes is to minimize the introduction of objectionable names, but they grant no warrant for the elimination or emendation of objectionable names, once these have been published. In the interest of good form, recommended procedures *should* be followed but they are not mandatory. This is clearly indicated by Article 36, Recommendations, in which it is expressly stated that certain names formed in a manner contrary to that which "should" be followed are not to be excluded as incorrect or inacceptable on this account.

There are literally thousands of generic names that in one or more particulars fail to accord with Recommendations accompanying the Rules. They are improperly translitterated; they combine modern patronymics with prefixes or suffixes derived from the classic languages; they employ improper connectives between roots; they are given the wrong ending and a gender changed from that of the root terms; and they show many other sorts of aberrations or infelicities. Most of these names are reckoned univer-

sally to be valid, nevertheless, and if it were not so, almost unending confusion and instability would ensue.

(3) *Formulation of generic names not explicitly circumscribed.*—Article 8 provides that "A generic name must consist of a single word, simple or compound, written with a capital letter, and employed as a substantive in the nominative singular." The Recommendations that follow list words suitable for generic names and specify others that are not advised. Use of the latter type of words, however, is not excluded either by the wording of Article 8 or by any statement in the Recommendations, and some names derived from such words have been in good standing for many years. Therefore, it is evident that any word may be used for a generic name no matter how derived, even though some words are obviously objectionable. The only restriction is imposed by Article 3 which states that "The scientific names of animals must be words which are either Latin or Latinized, or considered and treated as such in case they are not of classic origin."

(4) *Scope of authorization for emendation of names.*—Article 19 states that "The original orthography of a name is to be preserved unless an error of transcription, a *lapsus calami*, or a typographical error is evident."[1] An error may be introduced at any stage in the preparation of a paper from the original draft of the manuscript (*lapsus calami* or slip of the pen), through revision or typing of the manuscript (error of transcription), to the final printing (typographical error). The common definition of transcription is "the act of copying," but a secondary meaning is "transliteration." Recommendation a of Article 8, which states in part "the rules of Latin transcription [transliteration (see Appendix F)] should be followed," suggests that the term "an error of transcription" in Article 19 may refer not only to errors in copying but also to errors in transliterating. We interpret the term as used above, however, in its strict sense, recognizing that mechanical errors of inadvertence in the act of transliteration are correctable just as are those in transcription. Whether or not we are correct in this interpretation is immaterial because directions for transliterating are contained in the Appendix and, therefore, as pointed out in section 2 above, these directions are not mandatory and a generic name not transliterated in accordance with them is not necessarily erroneous.

The types of errors specified in Article 19 are similar in that they are mechanical and are in fact errors of the hand rather than of the mind. There are many examples of currently accepted scientific names, however, that are objectionable because they involve errors which have resulted from the authors' ignorance of the classical languages. Such an error is certainly not typographical, neither is it a *lapsus calami* nor an error of transcription in the proper sense of these terms. Therefore, Article 19 offers no provision for the emendation of such objectionable names any more than Article 8 forbids their introduction.

Article 20 states "In forming names derived from languages in which the Latin alphabet is used, the exact original spelling, including diacritic marks, is to be retained." The examples that follow in the text of the

[1] The present International Rules, adopted in 1913 (article 25 has since been emended) have evolved from a series of preceding rules dating, in spirit at least, from the Linnaean Code of 1751 and progressing through various standard codes since 1845. The first standard codes were adopted by various quasinational societies or societies representing certain specialized branches of zoological science and it was not until 1889 that the first International Zoological Congress, meeting in Paris, adopted a general code under which it was hoped that all zoologists would operate. Obviously this code was intended to supplant and supersede all previous codes and likewise the subsequent International Rules of 1901 and 1913 were intended to supersede their predecessors. The wording of the proposition that is now known as Article 19 has varied greatly, but because all of the older codes have been superseded by the Rules of 1913 only the wording of the latter now has significance. In this connection it should be noted that the official version of the modern Rules is in English, and Dobell (1939, p. 256) is therefore mistaken when he states that the Rules are in part translated erroneously and that the wording of the "original French" text of Article 19 allows the correction of misformed names. It should also be borne in mind that the Rules are to be applied retroactively. Although there is no statement to this effect in the zoological code, the implication is unmistakable and the botanical code (whose objectives are identical to those of the zoological code) states plainly that "They are always retroactive" (Briquet, 1935, p. 1).

Rules show that this Article is intended to apply to proper nouns. Other words of nonclassic origin are generally unsuitable for the formation of scientific names. Many place names and surnames, however, are differently spelled in different languages, or even in the same language, and all such spellings are correct as regards their use in formulating a generic name. For example, *Sochkineophyllum*, named for the Russian paleontologist whose name is variously written Sochkine, Soschkina, Sochkina, and Soshkina, is a valid generic name that is not emendable to agree with some other of the variant renderings of the surname.

(5) *Requirement of "evident" indication of error in original publication.*—Opinion 26 states in part "In the opinion of the Commission, to be 'evident' in the sense of this article [Art. 19] involves the presence (in the original publication) of clear evidence that the spelling in question is erroneous"; and further "In general it seems clear that the evidence in question must be contained in the original article, and must be of such nature that it is apparent to workers unacquainted with local conditions and local names."[2] This Opinion is clearly intended to define an "evident" error as an error that is equally evident to all, and thereby to prevent the correction of an error recognized by one claiming to possess special information.

(6) *Author's status in regard to emendation*—Article 30, which states "A generic or a specific name, once published, cannot be rejected, *even by its author*, because of inappropriateness" (our italics), clearly denies an author any special privilege over an inappropriate name. This principle may be reasonably and logically extended to include names which are objectionable for any other reason, and thereby it serves to suppress all claims of an original author's special privilege in the matter of emendation.

There is an understandable tendency for the author of a generic name to assume a proprietory interest in it, and the practice of appending an author's name to the name of his genus unfortunately encourages the idea that a generic name is more or less the personal property of the one who proposed it. The privilege accorded to all workers to propose new generic names, however, is attended with grave responsibilities to the entire science of zoology that are too often lightly assumed. After a name is once published it becomes a permanent part of the system of zoological nomenclature and we believe that its author possesses no rights or privileges concerning it that are not equally shared by all other zoologists. Consequently personal interest cannot be allowed to enter into the consideration of generic emendations and this matter must be approached by all in an entirely impersonal and dispassionate manner with the goal of stability clearly and constantly in view.

(7) *Emendation rarely permissible.*—Mechanical errors of the types specified in Article 19 are the only errors subject to emendation, and they may be corrected only if they are equally evident to all in the original published article. Errors are rarely so evident and consequently the emendation of generic names is seldom justified.

Summary.—The Rules must be applied strictly.

The Recommendations and Appendix are not parts of the Rules.

Any word may be used for a generic name, provided that it is treated as a Latin substantive.

Only mechanical errors are subject to correction.

An error must be equally evident to all in the original publication.

The original author possesses no special privileges.

[2] The words "In general" which begin this second quoted sentence introduce an element of uncertainty into the application of the principle expressed by Opinion 26. Do they mean that exceptions are allowable? This question cannot be answered entirely satisfactorily and it is obvious that if exceptions are to be permitted, differences of opinion are likely to arise and thereby uniformity in application is seriously endangered. Therefore, we believe that these words should be disregarded and that no exceptions should be permitted other than by specific action of the International Commission.

The Opinions are no more parts of the Rules than are Recommendations or the Appendix. This is made quite clear by the statement "An Opinion . . . has not the force of law, but . . . is a strong moral support . . ." (Stiles, 1914, paragraph 61, p. 879). The principle expressed in Opinion 26 is so important, however, that we believe it should be made an amendment to Article 19 and we propose to consider it an informal amendment.

Emendation of generic names is rarely permissible.

EXAMPLES OF EMENDED GENERIC NAMES

The following cases involving either actual or proposed generic emendations in paleontology have been selected for presentation from a larger group that has recently come to our attention. Each illustrates a more or less different aspect of the common problem.

Poteriocrinites versus *Poteriocrinus*

Miller (1821, p. 14) originally described and illustrated a Lower Carboniferous crinoid for which he used the generic name *Poteriocrinites*. This genus was recognized, using Miller's name, by Meek and Worthen (1866, p. 179, and other papers), Bassler (1938, p. 157), and Moore and Plummer (1938, p. 236, 1940, p. 40) but almost all authors during more than 100 years have employed another name, *Poteriocrinus*, that was introduced by Agassiz (1836, p. 197). This alteration of Miller's generic name clearly is indefensible under the Rules. No proper question of etymological or other sort can be adduced as a ground for suppression of the original name of this crinoid, and unless the general usage by authors of Agassiz's synonym should be made the basis of action by the Commission to set aside the Rules, *Poteriocrinites* must be recognized as a valid generic name. It seems inadvisable to propose such abrogation of the Rules, because far too many parallel cases are involved. Especially among crinoids there are numerous genera that originally were spelled with the ending *-crinites*. Most of these were arbitrarily and erroneously modified to carry the ending *-crinus*, but some were altered to *-blastus* or *-cystis* and even shifted from one to the other as judgments concerning classification changed. Article 32 of the Rules provides that "a generic or a specific name, once published, cannot be rejected, even by its author, because of inappropriateness" and further that "names are not to be rejected because of a claim that they indicate characters contradictory to those possessed by the animals in question."

Loxostomum versus *Loxostoma*

The foraminiferal genus *Loxostoumm* Ehrenberg (1854, pl. 17, fig. 19) has been treated, using the original spelling, in many papers. Some of these are by Cushman (1928, p. 252, 1931, p. 51, 1932, p. 341), Wickenden (1932, p. 91), and Thalmann (1935, p. 715, 1939, p. 456). In 1930, Howe (p. 329) emended the spelling of this genus to *Loxostoma*, basing this on the conclusion (credited to R. C. Moore) that *Loxostomum* was transcribed in an erroneous manner from the root Greek words, λοξος, oblique, and στομα mouth. Article 19 of the Rules was presumed to give authority for correction of this "error of transcription." *Loxostoma* Howe (1930) has been cited incorrectly as *Loxostoma* Ehrenberg (1854) by various writers (Howe, 1930; Cushman, 1933, p. 222, 1933a, p. 82, 1936, p. 59, 1940, p. 244; Galloway, 1933, p. 352; Coryell and Embich, 1937, p. 303; Albritton and Phleger, 1937, p. 348). Study of the grounds for emending *Loxostoma* indicates that neither a *lapsus calami* nor typographical error can be involved in this case, for Ehrenberg also proposed *Clidostomum*, *Grammostomum*, *Heterostomum*, *Otostomum*, *Phanerostomum*, *Ptygostomum* and *Selenostomum*. The root *-stomum* was repeatedly used. Also, it is clear that this was intended to signify mouth. Was there an error in transcription of the Greek word στομα? One hardly can argue that this is a direct transcription or transliteration into Latin. Rather, we must conclude that a spurious Latin word (*stomum*) for mouth was constructed, bearing a first declension neuter ending so as to correspond to the gender of the Greek noun. This reasoning necessitates recognition of *Loxostomum* as a valid name, though one that is faulty in construction. An error of transcription, as interpreted by the Rules, is certainly not "evident." It happens that *Cyclostomum* is cited in the Rules (Article 8,b) as a recommended example of a generic name formed by compounding Greek roots. *Ammochilostoma* Eimer and Fickert and numerous other genera having the ending *-stoma* are rightly compounded. *Cribostomum* Müller is like *Loxostomum*, poorly constructed but valid.

Another aspect of the case of *Loxostomum* versus *Loxostoma* emphasizes the instability of nomenclature that is introduced by emendation involving other than correction of

purely "mechanical" errors indicated in Article 19 of the Rules. Ehrenberg did not use *Loxostoma* and as matter of fact this name had already been published by Bivona (1838) for an entirely different thing. Existence of *Loxostoma* Bivona (1838) in the literature was overlooked when Howe emended Ehrenberg's *Loxostomum* so as to introduce a name that is plainly a homonym and therefore invalid. If we assume that this emendation was permissible and correct, should the changed designation of the genus be *Loxostoma* Ehrenberg (1854) or *Loxostoma* Howe (1930)? Referring to a foraminifer, the still-born name *Loxostoma* should be credited to Howe (1930), for without regard to compliance with Article 19, emended names are objective synonyms attributable to the author who first published the emendation and they bear the date of his publication (Opinion 125).

Let us suppose that the date of *Loxostoma* Bivona is 1858, instead of 1838. If *Loxostoma* the emended name, is attributable to Ehrenberg (1854), then *Loxostoma* Bivona (1858) would have to go out as a junior homonym, even though this name had never been used before Bivona introduced it. Obviously, such emendation, if allowable, would be highly disturbing and unsettling rather than stabilizing, and the only end served would be a pedantic conformance to etymological procedure.

As matters stand, we must conclude that both *Loxostoma* Bivona (1838) and *Loxostomum* Ehrenberg (1854) are valid terms in nomenclature, despite their similarity of form and identity of roots. This is clearly indicated in Article 36 and Opinion 25. *Loxostoma* Howe (1930) is a junior homonym of *Loxostoma* Bivona (1838) and a junior objective synonym of *Loxostomum* Ehrenberg (1854). On both grounds it is to be rejected.

Graphiadactyllis versus *Graphiodactylus*

Graphiadactyllis Roth (1929, p. 10) was proposed as a generic name for an ostracode having surface ornamentation described as like that of a fingerprint. The etymological sources of the generic name are implied in the original description, but it is obvious that the spelling only remotely approximates a correct transliteration of the Greek roots (γραφειν, to write, δακτυλος, finger). A few months after the original publication, the author emended the spelling to *Graphiodactylus* (Roth, 1929a, p. 292) and in this form the genus has been designated by others (Van Pelt, 1933, p. 333; Bassler and Kellett, 1934, p. 321). Was this correction, made by the author, permissible under the Rules? One might assert that the original spelling should stand because of Article 8k, which provides that generic names may consist of "words formed by an arbitrary combination of letters." On the other hand, the intent of the author that the generic name proposed by him should signify print of a finger is reasonably "evident" in the original publication, in the sense required by Article 19 and various opinions. Does this mean that anyone may validly emend the meaningless name *Graphiadactyllis* to one that clearly is based on the implied Greek roots? The author himself made such emendation, but it is to be noted that the Rules accord to an author no special privilege of changing a name that is denied to others. Indeed, if grounds for correction of a name are not such as to permit any worker to recognize them and act on them, an author cannot do so. Opinion 26 states that "to be 'evident,' in the sense of Article 19, involves the presence in the original publication of clear evidence that the spelling in question is erroneous," and further, that "the evidence in question must be contained in the original article and must be of such nature that it is apparent to workers unacquainted with local conditions and local names." The importance of evidence contained in the original publication and the narrowness of interpretation of what "is evident" are repeatedly stressed in various Opinions (26, 27, 29, 34, 36, 61 and others), but they are less clearly indicated in the summaries than in the full text and in the unanimous or nearly unanimous votes of the Commissioners.

The question raised about Roth's right to emend *Graphiadactyllis* has not been answered by the references to Opinion 26 and others just given. Can one find in Roth's original publication any of the three sorts of errors that are designated in Article 19 of the Rules as the sole grounds for emendation of a generic name? Certainly there is no indication of a typographical error. No casual inadvertence (slip of the pen) can be

claimed. Nothing really suggests possibility of an error in transcription (copying or transliterating). At least three letters in the name are derived from sources that must be guessed to be in the author's mind. *Graphiadactyllis* may be judged an infelicitous name but no valid ground whatever exists under the Rules for changing it.

Kurnatiophyllum versus *Kumatiophyllum*, *Cymatiophyllum*, *Cymateophyllum* and *Cymatophyllum*

An extreme and very unusual case of instability of a generic name is offered in the five variant designations of a Lower Carboniferous coral described by Thomson. Moreover, all of the names were used by the same author! The first published spelling was *Kurnatiophyllum* (Thomson, 1875, p. 273), but two years later this was emended to *Kumatiophyllum* (Thomson, 1877, p. 250). Subsequently, the name of the genus was written *Cymatiophyllum* Thomson (1878, p. 166), *Cymateophyllum* Thomson (1883, p. 471), and *Cymatophyllum* Thomson (1901, p. 480). Gregory (1917, p. 229) recognized this coral under the name *Kumatiophyllum*. Lang, Smith and Thomas (1940, p. 46) choose *Cymatiophyllum* as the proper designation of this genus.

The source of the first part of the name of this genus seems to be κυματος or κυματιας, meaning billowy, but this is only a reasonable inference. Correction of typographical errors or a slip of the pen is authorized by Article 19 of the Rules, and accordingly change from *Kurnatiophyllum* (a meaningless term) to *Kumatiophyllum* (a meaningful name) seems to be justified. The difference between these two names is very plausibly explained as an error in the original writing or printing. Correction is not justified on the ground of desirability of change from meaningless to meaningful but because of evidence of existence of an error of writing, printing or transcription. A strictly parallel case of error in printing "m" as "rn" is seen in publication of Meek's genus *Trachydomia* as *Trachydornia* (Meek, 1873, p. 216).

The spelling of *Kumatiophyllum* does not follow recommended procedure in transliterating the Greek letters of the first root word, and so the author subsequently undertook to emend the spelling to *Cymatiophyllum*. Whether or not this second alteration should have been made and is to be recognized, the third and fourth changes certainly can be said merely to compound confusion. For the reasons given by Knight (1941) in his discussion and considered in the following section of this paper, we agree with Gregory (1917) that *Kumatiophyllum* is the correct name of Thomson's genus, even though the first root used by him in compounding it might better have been transliterated in a different manner.

Kallimorphocrinus versus *Callimorphocrinus*

Kallimorphocrinus (J. M. Weller, 1930, p. 15) is correctly compounded and it is correctly transliterated except possibly as regards the initial letter. Although Weller's definite and specific intent to transliterate the Greek kappa as K, instead of C, was not mentioned by him, he has asserted orally and in letters that he deviated purposely from customary practice in transliteration, which would have produced *Callimorphocrinus*. Inasmuch as several species of *Kallimorphocrinus* were described by Weller and the name was correspondingly much used, no question can be raised as to existence of a *lapsus calami* or of typographical errors. Other workers, however, might infer that an error of transcription had been made and accordingly emend the spelling to *Callimorphocrinus*. This was done by Peck (1936, p. 283), Wanner (1937, p. 203), Strimple (1938, p. 3), Wright (1939, p. 51), Marez Oyens (1940, p. 344), Moore and Plummer (1940, p. 39), and Moore (1940, p. 61). Wright (1933, p. 204) originally accepted *Kallimorphocrinus* but later (1939) published the name as *Callimorphocrinus*. Bassler (1938, p. 120) adopted the original orthography of Weller. On learning that the spelling of *Kallimorphocrinus* by Weller was intentional, Moore nevertheless deemed that this was an error of intent on Weller's part and therefore just as fully subject to emendation as if it had been an inadvertent error of transcription. A two-fold question calls for consideration—whether transliteration of kappa as K conflicts with the Rules, no explanation or indication of special intent being given, and whether such

transliteration when purposely written (or any other intentional spelling) is rightly classified as an error of transcription.

No new generic name, presumably, is formulated by anyone without some measure of intent, but intent is difficult if not impossible to evaluate. Therefore, we believe that the special intent of an author in the spelling of a generic name can be of no significance unless a statement is included in the original publication or unless the author's intent is made equally evident in some other way. Consequently, Weller's intent is not important in connection with the question as to whether the original spelling of *Kallimorphocrinus* calls for change.

Does *Kallimorphocrinus* represent an error of transcription, as meant by Article 19 of the Rules? There are many hundreds of generic names, recognized as valid, that show deviations from classical procedure in transliteration. The deviations are not recommended, but once published, they are valid. Examples of generic names that resemble *Kallimorphocrinus* in being written *Kalli-*, instead of the much more common and correct *Calli-*, are *Kalligramma* Walther (1904), *Kalliphobe* Busch (1851), *Kallipterygia* Laporte-Castelnan (1832), *Kallirhynchia* Buckman (1914), *Kallispongia* Wright (1877), *Kallistaphis* Buckton (1881), *Kallistira* Hay (1908), *Kallitaxila* Kirkaldy (1901) and *Kallitrichia* Ottloingui (1898).

Opinion 12 states that "the generic name *Stephanoceros*, 1832, is to be used." . . . The Commission did not intimate that the final *-os* of this name should be emended to *-us*. Explicit denial that Greek letters "must" be transliterated in the recommended manner is shown, in Opinion 125, unanimously approved by the Commission, to the effect that emendation of *Boros* Herbst (1797) to *Borus* Agassiz (1846) is invalid, the latter name being regarded as an absolute synonym of the former. This case has been noted by Knight (1941) in his discussion. Opinion 23 states that "*Cheilodipterus* is a valid generic name," without indicating correction of the *ei* to *i*. Opinion 53 refers to the specific name *koilomatodon* without any suggestion that *koilo-* should be emended to *coelo-*. Opinion 76 frequently mentions *Oikopleura*, without indicating that this should be spelled with a *c* instead of a *k*. Opinion 81 refers to *Klinophilos*, 1899, and indicates that *Clinophilus*, 1903, an emended form of *Klinophilos*, is a synonym of *Klinophilos*. Opinion 90 reports denial by the Commission of recommended emendation of *Cheiromys* to *Chiromys*. These citations leave small room for doubt concerning procedure that is deemed sound. Errors of transcription are not at all common, as judged under the Rules, because deviation from *recommended* transliteration plainly is not deemed to be an *error*. Only in Opinion 36 is an error of transcription (or transliteration) definitely recognized to be evident.

An interesting item in connection with this discussion is the fact that a strictly correct transliteration of the root word κρινον, meaning lily, is not *crinus*, but *crinum*. It is a neuter noun and the ending of such Greek neuters in *-ον* is invariably written *-um* in Latin. Should the many scores of crinoid genera having names that end in *-crinus* be emended to *-crinum*, with accompanying changes in the form of specific terms to show neuter gender? No paleontologist would think seriously of such emendation and it is not called for under the Rules. Knight's (1941) observation that an erroneously introduced emendation of a generic name, although classed as a junior objective synonym, invalidates any subsequent use of the emended name (which would make a homonym), is worthy of special notice. This is clearly indicated by Opinions 120 and 125.

Stuartwellercrinus

Study of crinoids named *Cibolocrinus* by Weller (1909) has led to restriction of this genus (Moore and Plummer, 1938, pp. 225; 1940, p. 81) and to definition of a new genus called *Stuartwellercrinus* Moore and Plummer (1938, p. 305, 1940, p. 328).

Shortly after proposal of *Stuartwellercrinus*, Johannes Wanner, eminent paleontologist of the University of Bonn, who has done so much work on the Permian echinoderm fauna of Timor, wrote a letter saying that for reasons of euphony this generic name should be emended by inserting an *i* before *-crinus*. It is true that connective vowels are commonly employed in forming generic names based on patronymics, and the vowels thus used are the ones—generally "i" or "o"—that function as connectives for

roots of compound Greek terms. The connective in *Stuartwellercrinus* was omitted because the name seems as easy to pronounce without it as with it. Granting, however, that the name might better have been proposed with a connective vowel, it seems clear that emendation cannot be made validly now. Neither a *lapsus calami* nor typographical error is evident in the original publication, and no basis is seen for a claim that the name as published represents an error of transcription.

A letter from Carl C. Branson, of the University of Kentucky, raises another question concerning emendation of *Stuartwellercrinus*. He points out that Recommendation *he* under Article 8 provides that "with patronymics consisting of two words, only one of these is used in the formation of a generic name" and accordingly he says that *Stuartwellercrinus* is definitely in need of correction. It is necessary to admit that this generic name does not conform to recommended practice in compounding names based on patronymics, but it is firmly our view that in spite of this, *Stuartwellercrinus* is not emendable. Phraseology of the Recmendations themselves is sufficiently indicative of their far from mandatory nature. As already noted, the Rules say "must" and "shall," whereas the Recommendations consistently say "should," "is preferable," "may be," "is requested," "is recommended," "is well to avoid," and "poor but not to be rejected." If there is doubt about the validity of names that run counter to some Recommendation, but not to the Rules, this doubt is easily removed in all but a very few cases by study of the Opinions. Many generic names are based on two patronymics, as illustrated by *Augustohahnia* Schmidt (1920), *A. Thienemannia* Viets (1921), *Carlobruchia* Weise (1906), *Carolibergia* Mercerat (1899), *Carolobatea* Stebbing (1899), *Emeryopone* Forel (1912), *Guy-Valvoria* Vayssiere (1906), *Harriwhitea* G. M. Mathews (1912), *Henricodohrnia* Breddin (1901), *Raatzbrockmannia* Schmidt (1924), *Ramakrishnaia* Bolivar (1918), and the following names by Ameghino (1901), *Albertogaudrya, Caroloameghinia, Carolodarwinia, Carolozittelia, Edvardocopeia, Edvardotrouessartia, Ernestokokenia, Ernestohaeckelia, Guglielmoscottia, Guglielmofloweria, Henricosbornia, Josepholeidyia* and *Paulogervaisia*. These, like *Stuartwellercrinus*, are not "recommended" generic names but they must be accepted as valid in so far as orthography is concerned.

CONCLUSIONS

The International Rules have been set up primarily for the purpose of stablizing nomenclature and if stabilization is to be achieved and maintained difference of opinion cannot permissibly be expressed by variant spellings of generic names. Many published names are offensive to the classically trained worker, but the fact that a name is objectionable is not sufficient basis for the assumption that such a name is validly emendable. As stated in Article 19, the original spelling of a name may be changed *only* if an error of transcription, a *lapsus calami* or a typographical error is evident. Opinion 26 establishes the principle that evidence justifying emendation must be contained in the original publication and that this evidence must be apparent to one possessed of no special information. Otherwise, no one, not even the original author, is privileged to emend a name. Deviatlon from recommended classical procedure in transliteration of Greek roots or incorrect compounding of names do not in themselves produce invalid names, and such names, although faulty, are not emendable, once they have been published.

Article 19 grants permission for the correction of certain errors, but it does not state that such corrections must be made. We believe, however, that every faulty name which is validly emendable should be corrected promptly in order that uniformity and stability may be attained as early as possible.

We believe that the entire subject of emendations to zoological names should be considered by the International Commission on Zoological Nomenclature. An Opinion should be rendered that will fully clarify certain ambiguities that are at present inherent in the Rules. In the meantime, we recommend that authors refrain from specifying the derivations of new generic names and thereby lessen the likelihood of claims that these names are faulty and therefore subject to correction.

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AN IMPROVED TECHNIQUE FOR PHOTOGRAPHING PEEL SECTIONS OF CORALS

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While engaged in the study of some Chester corals at Walker Museum, University of Chicago, the writer achieved notable success photographing peel sections by controlling the angle of incidence of the light upon the peel and the nature of the background.

The corals are prepared by rough grinding on a power lapidary wheel, then finished by hand grinding upon a glass plate with number 600 carborundum abrasive in water. The prepared surfaces are etched in dilute hydrochloric acid long enough to remove minute scratches and, therefore, to heighten contrast between the coralline structure and the matrix. After being dried, the specimens are embedded in sand with the exposed plane surface precisely horizontal. Two applications of "peel dope"[1] are found most satisfactory, with about a 12 hour interval between applications in order to permit thorough drying, great care being taken to

[1] Pyroxcote, Clear Solution B-14506, manufactured by Pyroxylin Products, Inc., Chicago, Illinois.

avoid bubbles or an excess of "dope." Peels are removed from the coral by sliding a single-edged safety razor blade between the peel and the surface of the specimen, being careful not to scratch either.

The peel section is bounded by one essentially plane surface and another surface bearing (a) the impressions of large calcite crystals constituting the matrix of the coral and (b) of minute calcite crystals constituting the formerly organic portions.

The finished peel is supported by friction between the two glass plates of the negative holder removed from an enlarger; thus, there are no pins or clamps to obscure portions of the peel. The holder containing the peel is now placed before the camera with the side of the peel that once touched the coral now facing toward the source of illumination. An ordinary strong microscope lamp emitting nearly parallel light is used, but the usual blue filter is removed in order to render the light as harsh as possible. The lamp is located on the side of the negative holder away from the camera and to one side so that the angle between the light rays and the plane of the peel is about 30°. As close to the negative holder as it can be placed without obstructing the illumination is a dull black background upon which light should not fall directly from any source. Exposures should be made without any light on, other than the one in the microscope lamp, in order to eliminate reflections from the glass or peel. Exposures are made with the iris diaphragm stopped down to about *f*.32 in order to render all details distinctly without overexposing some details.

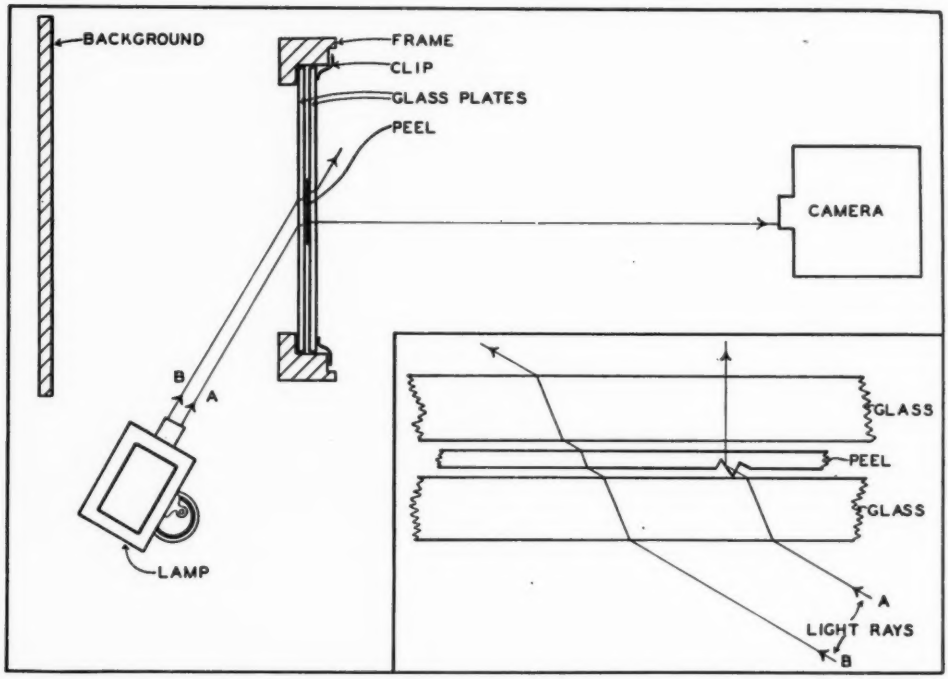

FIG. *1*—Apparatus for photographing peel sections.

This photographic technique is based upon three well-known optical phenomena. When light enters a translucent substance having two parallel plane surfaces, the light rays will leave the substance with their paths parallel to the paths of the same rays before they entered that substance, al-

though the rays will be offset in space because of refraction within the substance. Secondly, when rays of light strike a translucent colorless substance consisting of many minute surfaces variously orientated in space, many rays are totally reflected and the substance appears light because of reflection of light rays. Finally, when a substance has a very different index of refraction from that of the surrounding medium, irregularities on the surface of the substance are apparent because the rays of light are not able to enter it without suffering considerable refraction and some rays undergo total reflection. On the other hand, if imbedded in some substance of nearly the same index of refraction, the irregularities of the peel will be filled by the imbedding substance and light rays can enter the peel with little or no refraction, hence, irregularities are effectively minimized.

Best photographic results have been obtained by placing the lamp so that the angle between the light rays and the plane of the peel does not exceed 30°. In figure 1 the arrangement of the apparatus is shown in plan view and a portion shown in the insert much enlarged and simplified in order to demonstrate the paths of certain rays. Since the glass plates have parallel plane surfaces, the paths of light rays after leaving them and before entering the glass must be parallel (Lewis, 1926). Similarly, ray "B" strikes an impression of calcite in the matrix whose surface is parallel with the opposite surface of the peel and the path of this ray after leaving the peel will be parallel with the other paths of the same ray in air. Ray "B" will pass through the last plate of glass without having been refracted enough on its course to travel to the camera, and the black background will be present on prints.

On the other hand, ray "A," after leaving the first glass plate, strikes a peel surface perpendicular to its path and passes into the peel without being refracted. The ray strikes the other surface of the irregularity at an angle of 60° to the normal to that surface and is totally reflected.[2] Now the path is normal to the upper surface of the peel and to the surfaces of the glass, hence, it travels straight to the camera without being refracted. This is the simplest special case but many variations would exist. Rays striking numerous, minute, heterogeneously orientated, impressions of formerly organic calcite will be variously refracted, reflected, and, in part, totally reflected from one surface or another.

The effect of various chance paths which the rays take is to make the coralline impressions on the peel appear very bright on the prints, whereas, impressions of larger crystals permit the black background to appear in the prints. Minute textural variations, such as the differentiation between the septal lamella and the septal stereozone can be photographed readily, without utilizing stains, dyes, powders, and imbedding of peels in oils. No thin sections have to be sliced and painstakingly ground; no camera lucida or other drawings need be made. The finished prints appear as do peels held up to a light, except that the prints are better because the matrix is automatically blacked out.

The chief difficulty with the method is that with decrease in size of the crystals in the matrix, the prints become increasingly obscured with the traces of planes between crystal faces and between cleavage fragments.

The writer is indebted to Dr. D. J. Fisher, of the University of Chicago, for reading the manuscript and making helpful suggestions.

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[2] The critical angle for Pyroxcote is 41°36′, since its n (index of refraction) = 1.507, as determined by Mr. R. A. Rowland on an Abbé refractometer.

MANUSCRIPT RECEIVED BY THE EDITOR NOVEMBER 7, 1941.

FAUNA OF THE GLENDON FORMATION AT ITS TYPE LOCALITY

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ABSTRACT—Despite the widespread correlation of many faunas from other states and countries with the so-called "Middle Oligocene," or Lower Oligocene Glendon formation of Alabama, no detailed study of the faunal content of the formation at its type locality has previously been published. Available literature records only the 4 species *Ostrea vicksburgensis*, *Pecten poulsoni*, *P. anatipes*, and *Clypeaster rogersi* plus an unidentified *Lepidocyclina*. The fauna of the Glendon formation has been described from other than the type locality. This report is essentially a checklist, bed by bed, of the species of invertebrate fossils present in the softer layers. As satisfactory material was obtained from only a few places, photographs are included to show where the material was obtained.

The name Glendon limestone first appeared in print in 1917 in a paper by Hopkins,[1] who used it for the upper member of the Marianna limestone. Hopkins credited the name to an unpublished manuscript by C. W. Cooke. He gave the following brief description of the member at its type locality:

> The upper part of the "chimney rock" and the Glendon member are well exposed at Glendon, a flag station on the Southern Railway east of Jackson, the type locality of the Glendon member. Here about 15 feet of Glendon limestone, of typical "horsebone" appearance, overlies an equal thickness of soft chalky limestone, composed in some beds of masses of *Orbitoides* (thin, round, flat shells from three-fourths to 1 inch or more in diameter).

Cooke[2] likewise considered the Glendon to be a member of the Marianna the following year. However, five years later, Cooke[3] elevated the Glendon to formational rank. In doing so, he assigned the chert beds near Bainbridge, Georgia; Geneva, Alabama; Holmes County, Florida; and even the Salt Mountain limestone to the formation. He correlated it with the Antigua formation of the Leeward Islands, which in turn was correlated with the *Heterostegina* zone of the Gulf Coast salt dome region, by later workers, on the basis of the supposed presence in the latter of *Heterostegina antillea*,—whence the origin of the term "middle Oligocene."

Cooke[4] considerably clarified his concept of the Glendon formation as the result of a summer's field work in Alabama. He gave the following description and section of the formation at its type locality:

> "There are two very different facies of the Glendon formation. West of Conecuh River the formation consists of more or less impure limestone; east of Conecuh River it probably consists of limestone under cover, but where it is exposed at the surface it consists of sand, clay, gravel, and residual lumps of silicified limestone or chert. In the western area the limestone is probably nowhere thicker than 40 feet, and it averages about 15 feet thick. No very reliable estimate of the thickness of the sandy facies has been made, but the formation probably does not much exceed 100 feet in thickness and may be considerably less. In the western area the limestone lies conformably between the Marianna "chimney rock" and the Byram marl, but the siliceous facies in the east overlaps across the Ocala limestone, the Lisbon formation and part of the Tallahatta formation. On all these formations, therefore the Glendon rests unconformably.
>
> The type locality is Glendon, a flag station on the Southern Railway between Jackson and Walker Springs, Clarke County, in the southern part of sec. 31, T. 7 N., R. 3 E. The following section at Glendon was measured at a "chimney rock" quarry on the north side of the railway tracks.

Section at Glendon

	Feet
Glendon limestone:	
3. Hard, cream-colored to buff, semi-crystalline limestone weathering with irregular tubular cavities; the top is a smooth ledge of yellowish limestone containing (U.S. Geological Survey 7162) *Lepidocyclina* sp., *Ostrea vicksburgensis*, *Pecten poulsoni*, *P. anatipes*, *Clypeaster rogersi*, and other fossils.....	18–20

[1] Hopkins, O. B., Oil and gas possibilities of the Hatchetigbee Anticline, Alabama, U. S. Geol. Surv. Bull. 661H, 1917 (1918) pp. 298, 300.

[2] Cooke, C. W., Correlation of the deposits of Jackson and Vicksburg ages in Mississippi and Alabama, Wash. Acad. Sci. Jour., vol. 8, 1918, pp. 187, 195.

[3] Cooke, C. W., The correlation of the Vicksburg group, U. S. Geol. Surv. Prof. Paper 133, 1923, pp. 3–9.

[4] Cooke, C. W., Alabama Geol. Surv. Special Rept. no. 14, 1926, p. 285.

FIG. 1—East quarry at Glendon, Alabama. The black line indicates points 20 feet above the railroad tracks, and marks the base of the Glendon formation. The lowest circle indicates the place where sample No. 2 was obtained; the circle on the left marks the position of sample No. 4 and the circle in the center marks the position of sample No. 5. Samples Nos. 1 and 3 were obtained from the west quarry, about 100 yds. behind the trees shown on the left. Sample No. 6 (see fig. 2) was obtained about 120 feet directly back of the quarry face shown in this photograph.

Marianna limestone:	
2. "Chimney rock," harder than bed 1; a little of this bed has been quarried	9
1. Soft, cream-colored to white chalky limestone or "chimney rock"; has been quarried; base of exposure level with railway tracks; contains *Lepidocyclina mantelli* and many Bryozoa	11

Later work has changed some of the early concepts of the Glendon formation. Cooke[5] has termed the cherts near Bainbridge, Georgia the Flint River formation. The 100 feet of sands and gravels referred to the Glendon formation in eastern Alabama is probably for the most part Pleistocene stream deposits which include blocks of chert and limestone of various ages. Cooke,[6] however, reported "the best known and thickest exposure of the Glendon limestone" at Falling Water sink, 4 miles south of Chipley, Florida, where the thickness was given as 65 feet of white to cream-colored, soft, granular limestone. This exposure at Falling Water bears considerable resemblance to the Glendon at its type locality, both lithologically and faunally, though it will probably be in part correlated with the Suwannee limestone. Still more recently Cooke[7] has indicated that the Glendon is absent entirely in eastern Alabama and western Florida, which would include the exposure at Falling Water. The correlation of the Salt Mountain limestone with the Glendon formation

[5] Cooke, C. W., Amer. Assoc. Petroleum Geologists Bull. vol. 19, no. 8, 1935, pp. 1170–1171.

[6] Cooke, C. W., and Mossom, S., Twentieth Ann. Rept., Fla. Geol. Surv., 1929, p. 70.

[7] Cooke, C. W., U. S. Geol. Surv. Bull. 867, 1936, p. 97.

was corrected some years ago by Blanpied[8] when he demonstrated that the Salt Mountain was Wilcox Eocene in age.

It is curious that with all of the controversies arising over the term Glendon, no detailed study has been made of the fauna of the type locality. Cooke submitted collections to Dr. Cushman[9] for study, concerning which Cushman remarked:

> The collections from the Glendon [at Glendon] which I have examined were obtained mostly from the softer layers, and from these it is possible to wash out a certain number of identifiable Foraminifera, but most of the forms are not well preserved and can be identified, as a rule, only by comparison with better specimens from other divisions. The species and varieties here recorded from the Glendon number 43, of which 3 are peculiar to it. . . .

No species, however, were listed by Cushman from the type locality. His 43 species came from five separate localities: Glass Bayou, Vicksburg, Miss.; 4 mi. E. of Brandon, Miss.; McGowans Bridge over the Conecuh River; 10 mi. E. of Bay Springs, Miss.; and 200 yds. north of Salt Creek on the Jackson-Rockville road, Alabama. None of these localities are near Glendon, and three of them are in another state. Because of Cushman's difficulty in obtaining satisfactory material from the type locality, it was thought advisable to show by means of photographs, figures 1 and 2, where the species included in my checklist were obtained.

FIG. 2—Photograph of uppermost exposure of Glendon limestone at Glendon, Alabama. Sample 6 was obtained from the softer material beneath the hard limestone ledge at an elevation of 42.7 feet above the railroad tracks, or 22.7 feet above the base of the formation as exposed in the east quarry.

The contention may be made by some that the lower samples, here assigned to the Glendon formation, are in reality Marianna because they carry *Lepidocyclina mantelli*. I

[8] Blanpied, B. W., Shreveport Geological Soc., Guidebook 9th. Ann. Field Trip, 1932, p. 31; 11th. Ann. Field Trip, 1934, p. 31.

[9] Cushman, J. A., U. S. Geol. Surv. Prof. Paper 133, 1923, p. 12.

CHECKLIST OF FOSSILS OCCURRING AT GLENDON, ALABAMA

	Marianna	Glendon				
	1	2	3	4	5	6
FORAMINIFERA:						
Angulogerina byramensis (Cushman)	×		×			×
Angulogerina rugiplicata Cushman			×			
Angulogerina vicksburgensis Cushman						×
Anomalina bilateralis Cushman	×		×			
Asterigerina subacuta Cushman			×			×
Baggina xenoula Hadley						×
Bifarina sp.			×			×
Bolivina byramensis Cushman	×		×			×
Bolivina cookei Cushman			×			
Bolivina mississippiensis Cushman	×					×
Bolivina cf. *B. tongi* Cushman						×
Bolivinella subpectinata Cushman	×					
Bulimina sculptilis Cushman						×
Cancris sagra (d'Orbigny)						×
Cassidulina laevigata d'Orbigny						×
Cassidulina crassa d'Orbigny			×			
Cibicides cf. *C. choctawensis* Cushman and McGlamery			×			×
Cibicides lobatulus (Walker and Jacob)	×		×			×
Cibicides mississippiensis (Cushman)	×		×			×
Cibicides pippeni Cushman and Garrett	×		×			×
Cibicides pseudoungerianus (H. B. Brady)						×
Discorbis arcuato-costata Cushman	×					
Discorbis orbicularis (Terquem)	×		×			×
Discorbis patelliformis (H. B. Brady)			×			
Discorbis subauracana Cushman						×
Discorbis n. sp.			×			×
Entosolenia laevigata (Reuss)						×
Eponides advena (Cushman)			×	×		
Eponides byramensis (Cushman)	×		×	×		×
Eponides mariannensis (Cushman)	×	×	×	×	×	×
Eponides vicksburgensis Cushman and Ellisor				×		
Frondicularia zeta Cole			×			
Gaudryina gardnerae Cushman			×			×
Gaudryina youngi Howe			×			×
Globigerina sp.	×		×			×
Globulina gibba d'Orbigny	×	×	×	×	×	×
Globulina inaequalis caribbaea d'Orbigny	×		×			
Globulina minuta (Roemer)						×
Guttulina austriaca d'Orbigny			×			
Guttulina irregularis(d'Orbigny)	×		×	×		×
Guttulina problema d'Orbigny	×					×
Gypsina rubra d'Orbigny	×	×	×	×	×	×
Gypsina vesicularis (Parker and Jones)			×			×
Gyroidina vicksburgensis (Cushman)	×		×			×
Karreriella advena (Cushman)			×			
Lagena cookei Cushman	×		×			×
Lagena sulcata (Walker and Jacob)	×		×			×
Lenticulina convergens (Bornemann)	×		×			
Lepidocyclina mantelli (Morton)	×	×	×	×		
Lepidocyclina supera (Conrad)					×	×
Liebusella byramensis (Cushman)	×	×	×	×	×	
Liebusella byramensis extans (Cushman)			×			
Liebusella byramensis turgida (Cushman)			×			
Loxostoma hiwanneense Howe						×
Marginulina n. sp. [large]			×			×
Massilina occlusa Cushman			×			
Nodosaria vertebralis (Batsch)	×	×	×	×		
Nonion applini Howe and Wallace	×					×
Nonion danvillense Howe and Wallace						×

CHECKLIST OF FOSSILS OCCURRING AT GLENDON, ALABAMA—*Continued*

	Marianna	Glendon				
	1	2	3	4	5	6
FORAMINIFERA—(*Continued*):						
Nonion planatum Cushman and Thomas	×					×
Operculinoides muirii Barker					×	×
Operculinoides vicksburgensis Vaughan and Cole					×	×
Palmula caelata (Cushman)	×		×	×		
Planulina cf. *P. alazanensis* Nuttall						×
Planulina byramensis (Cushman)	×		×			×
Polymorphina advena Cushman	×		×			×
Polymorphina frondea (Cushman)	×					
Pulvinulinella sp. [large]			×			
Pyrgo inornata (d'Orbigny)			×			
Pyrulina gutta (d'Orbigny)	×		×			
Reussella spinulosa glabrata (Cushman)	×		×			
Robulus cultratus Montfort	×	×	×	×		
Robulus submamilligera (Cushman)			×			
Robulus vicksburgensis (Cushman)	×		×	×		
Saracenaria italica de France	×		×			
Siphonina cf. *S. advena* Cushman [carinate]	×		×			×
Siphoninella byramensis Cushman			×			
Spirillina vivipara Ehrenberg	×		×			×
Textularia cf. *T. conica* d'Orbigny			×			
Textularia mississippiensis alabamensis Cushman	×		×			×
Textularia subhauerii Cushman		×	×	×		×
Textulariella sp.			×			
Triloculina rotunda d'Orbigny						×
Triloculina trigonula (Lamarck)						×
Uvigerina vicksburgensis Cushman and Ellisor	×		×	×		
Vaginulina elegans d'Orbigny	×		×			
Virgulina vicksburgensis Cushman						×
BRYOZOA:[1]						
Acropora saillans Canu and Bassler	×	×	×	×		
Adeonellopsis cyclops Canu and Bassler		×	×	×	×	×
Adeonellopsis grandis Canu and Bassler	×					
Catenicella subseptentrionalis Canu and Bassler			×			
Crisia hornesi Reuss	×		×	×		×
Crisulipora prominens Canu and Bassler	×					
Cyclicopora spongiopsis DeGregorio	×	×				×
Desmeplagioecia tenuis (Reuss)	×					
Diaperoecia clava Canu and Bassler	×	×	×	×		×
Diaperoecia orbiculata Canu and Bassler	×					×
Didymosella crassa Canu and Bassler	×		×			×
Diplopholeos lineatum Canu and Bassler	×					
Enoplostomella crassimuralis Canu and Bassler						×
Enoplostomella n. sp.	×					
Enoplostomella vallata Canu and Bassler	×			×	×	×
Exchoecia rugosa Canu and Bassler	×	×	×	×	×	×
Fedora pusilla Canu and Bassler			×			
Filisparsa atomicula Canu and Bassler	×					
Filisparsa bini Canu and Bassler	×					

[1] In this checklist the Bryozoan nomenclature used follows Canu and Bassler, U. S. Nat. Mus., Bull. 106, 1920, as that report is the principal report dealing with American early tertiary Bryozoa. It should be noted, however, that Bassler in Fossilium Catalogus, I: Animalia, pars. 67, 1934, has indicated that the following generic names should be changed to be in accord with the rules of zoological nomenclature: *Acropora* Reuss, 1869 = *Porina* d'Orbigny, 1852; *Diplopholeos* Canu and Bassler, 1917 = *Velumella* Canu and Bassler, 1917; *Lunulites* Lamarck, 1816 (not Lamarck, 1812) = *Reptolunulites* d'Orbigny, 1852; *Mecynoecia* Canu, 1918 = *Entalophora* Lamouroux, 1821; *Membrendoecium* Canu and Bassler, 1917 = *Amphiblestrum* Gray, 1848; *Metrarabdotus* Canu, 1914 = *Trigonopora* Maplestone, 1902; *Peristomella* Levinsen, 1902 = *Escharoides* Milne-Edwards, 1836.

CHECKLIST OF FOSSILS OCCURRING AT GLENDON, ALABAMA—*Continued*

	Marianna	Glendon				
	1	2	3	4	5	6
BRYOZOA—(*Continued*):						
Filisparsa laxata Canu and Bassler			×	×		×
Filisparsa simulator Canu and Bassler	×					
Filisparsa typica Manzoni	×					
Floridinella vicksburgica Canu and Bassler	×	×	×	×		×
Hippodiplosia magniporosa Canu and Bassler	×					
Hippomenella capitmortis Canu and Bassler						×
Hippomenella costulata Canu and Bassler	×					
Hippomenella transversora Canu and Bassler			×			×
Holoporella discus Canu and Bassler	×		×	×		
Holoporella seposita Canu and Bassler	×		×	×	×	×
Hornera porosa Stoliczka	×		×	×		
Idmonea grallator Canu and Bassler	×	×	×	×		×
Idmonea triforata Canu	×	×	×	×		×
Kleidionella verrucosa Canu and Bassler				×		
Lacerna hexagonalis Canu and Bassler	×					×
Lichenopora goldfussi (Reuss)	×	×	×	×		×
Lunulites distans Lonsdale	×	×	×	×	×	×
Mastigophora dutertrei (Savigny-Audouin)				×		×
Mastigophora hyndmanni (Johnston)			×			×
Mecynoecia lunata Canu and Bassler	×	×	×	×	×	×
Mecynoecia proboscidea Milne Edwards	×	×	×	×		×
Mecynoecia semota Canu and Bassler	×					×
Membraniporidra spissimuralis Canu and Bassler	×	×	×	×	×	×
Membraniporina tubulosa Canu and Bassler	×	×	×	×		
Membrendoecium rectum Canu and Bassler			×	×		
Metracolposa sp.			×			
Metrarabdotus monoliferum (Milne-Edwards)	×		×		×	
Microecia hirta Canu and Bassler				×		
Micropora coriacea (Esper)	×	×	×		×	
Nellia oculata Busk	×	×	×	×		×
Oncousoecia varians (Reuss)						×
Partretocycloecia exilis Canu and Bassler	×	×		×		
Perigastrella n. sp.	×					
Perigastrella plana Canu and Bassler		×	×		×	×
Perigastrella rectilineata Canu and Bassler	×					
Peristomella coccinea (Abilgaard)	×		×			×
Peristomella coccinea resupinata Manzoni	×					
Plagioecia discoidea Canu and Bassler	×	×	×	×		×
Plagioecia hirta Canu and Bassler	×					
Platonea clavata Canu and Bassler						×
Pleuronea fenestrata (Busk)	×					
Porella crassoparies Canu and Bassler	×					
Porella cylindrica Canu and Bassler	×					
Proboscina cranei Canu and Bassler	×					
Puellina inarmata Canu and Bassler			×			
Puellina radiata (Moll)	×					
Puellina simulator Canu and Bassler				×		
Retepora laciniosa Canu and Bassler	×	×	×	×		×
Rosselinana parvipora Canu and Bassler					×	×
Scrupocellaria clausa Canu and Bassler			×	×		×
Scrupocellaria cookei Canu and Bassler						×
Scrupocellaria milneri Canu and Bassler		×	×	×	×	
Scrupocellaria resseri Canu and Bassler	×					
Scrupocellaria triangulata Canu and Bassler	×		×	×		×
Scrupocellaria williardi Canu and Bassler		×	×	×		
Semihaswellia exilis Canu and Bassler	×		×	×		×
Smittina ampla Canu and Bassler						×
Smittina n. sp. 1	×					

CHECKLIST OF FOSSILS OCCURRING AT GLENDON, ALABAMA—*Continued*

	Marianna	Glendon				
	1	2	3	4	5	6
BRYOZOA—(*Continued*):						
Smittina n. sp. 2	×					
Smittina n. sp. 3	×					
Stamenocella grandis Canu and Bassler	×		×	×		
Stamenocella inferaviculifera Canu and Bassler	×	×	×	×		×
Steganoporella vicksburgica Canu and Bassler						×
Stephanosella entosoma (Reuss)	×					
Stomachetosella crassicollis Canu and Bassler				×		×
Stomatopora polygona Canu and Bassler	×					
Tubucellaria vicksburgica Canu and Bassler	×	×	×	×		×
Trypostega inornata (Gabb and Horn)	×				×	
Umbonula ceratomorpha (Reuss)			×			×
Velumella ? sp.			×	×	×	×
BRACHIOPODA:						
Argyrotheca? sp.	×		×	×	×	×
ECHINOIDEA:						
Cidaris sp. [fragments]	×		×			
Clypeaster rogersi (Morton)	×		×		×	
MOLLUSCA:						
Pecten anatipes (Morton)	×				×	
Pecten cf. *P. poulsoni* (Morton)	×		×		×	×
OSTRACODA:						
Bairdia hiwanneensis Howe and Lea			×			
Bairdia woodwardsensis Howe and Law			×			×
Bairdoppilata taxodonta Howe and Law		×	×	×	×	×
Brachycythere russelli Howe and Lea	×		×			
Bythocypris gibsonensis Howe and Chambers	×		×			
Cythereis blanpiedi Howe			×			
Cythereis blanpiedi melvinensis Howe	×					
Cythereis? *mcguirti* Howe	×		×			×
Cythereis vicksburgensis Howe	×		×			×
Cythereis sp. [spiny]	×					
Cytherella hannai Howe and Lea	×		×			
Krithe hiwanneensis Howe and Lea	×					
Paracytheridea woodwardsensis Howe and Law	×					

do not feel, however, that it is my place to revise the Glendon, but merely to show what it contains at its type locality, as it was defined by its author. To do this, even, has not been entirely simple. In the first place there are two old quarries at Glendon. One of them truncates the end of a long ridge and gives an excellent exposure of the Glendon formation in a face which approximately parallels the railroad. In this quarry only about 7 or 8 feet of Marianna limestone is exposed at the present time. The other quarry lies on the western side of the ridge, and parallels it. This western quarry exposes fully 20 feet of Marianna, but only the basal few feet of the Glendon formation is exposed at the top of the cut. I have assumed that the east quarry is the one mentioned by Cooke in his designation of the base of the Glendon formation, because a slight north, or northwesterly apparent dip is shown on the base of the Glendon in the west quarry, amounting to perhaps as much as two feet in the length of the exposure. There is a discrepancy between the thickness-figures given by Hopkins and those given by Cooke. Fortunately, however, Cooke starts his section at the railroad tracks, as shown in a

preceding quotation, and places the base of the Glendon 20 feet above the tracks. Assisted by Dr. Robert O. Vernon of the Florida Geological Survey, I ran a line of levels from the railroad tracks to the highest exposure at the type locality. The dark line on the photograph, figure 1, was drawn to indicate where a plane 20 feet above the railroad tracks would intersect the face of the east quarry. Inasmuch as Cooke is the author of the formation, I felt I must assume that this line marked the base. Regardless of whether it marks a significant point of faunal change, it certainly coincides with a lithologic break. Above this point the limestones are mostly hard, with only minor soft layers from which microfossils may be obtained.

Assuming, however, that this line 20 feet above the railroad tracks marks the base of the Glendon formation, its thickness is somewhat greater than has been previously reported. Fossiliferous sample No. 6 in my checklist was obtained beneath a hard ledge of limestone (fig. 2) about 120 feet back from [i.e., northwest of] the face of the east quarry shown in figure 1. The sample was obtained from a point 22.7 feet above the base of the Glendon formation in the east quarry, and the top of the ledge lies at an elevation of 24.3 feet above the base. The total thickness of the Glendon may not be exposed at its type locality, as the hills farther back from the quarry face are mantled with terrace gravel. It is probable, however, that slightly more than 25 feet of the formation is exposed here, as a slight dip to the north or northwest is indicated from exposures in the west quarry.

List of Samples

1. Marianna limestone in the west quarry at elevations 6–8 feet below the base of the Glendon limestone.
2. Glendon limestone in the east quarry 18 inches above the base of the formation. (See fig. 1.)
3. Glendon limestone on the slope above the west quarry, beneath a hard ledge and two feet above the base of the formation.
4. Glendon limestone in the east quarry five feet above the base of the formation. (See fig. 1.)
5. Glendon limestone in the east quarry 12–14 feet, inclusive, above the base of the formation. (See fig. 1.)
6. Glendon limestone beneath a hard limestone ledge 120 feet northwest of the east quarry, at an elevation of 22.7 feet above the base of the formation. (See fig 2.)

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HALYMENITES, A MARINE SANDSTONE INDICATOR[1]

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Abstract—The abundance of *Halymenites* in marine sandstones of Texas is of considerable value in studying the stratigraphy and sedimentation of the Eocene.

Throughout the Eocene and upper Cretaceous sandstones of Texas the peculiar fossil "borings," *Halymenites major* Lesquereux are very common. Stenzel[2] has recently referred to these fossils in a description of the Eocene beds of Leon County, Texas, as follows:

These pipes are composed of ferruginous indurated sand—that is, of Newby glauconitic sand—and are surrounded by Carrizo sand. Their color is yellow, orange, and vermillion-red. They are one inch to two inches in diameter. The length is indeterminate because they are always broken. They end bluntly rounded. The outside surface has numerous crowded bumps. These bumps are the same size on all pipes even if the diameters of the pipes differ. The bumps are about a quarter of an inch wide in horizontal and somewhat shorter in vertical direction. They protrude about one-eighth to one-sixteenth of an inch from the surface and cover the entire surface of the pipes.

[1] Published by permission of The Texas Company.

[2] H. B. Stenzel, Geology of Leon County, Texas Univ. Bull. No. 3818, 1938, pp. 68–70.

Occasionally some of the bumps are arranged in obscure, horizontal rows. The bumps and outside of the pipes are more firmly cemented than the core, which consists of friable sandstone. The pipes are very similar to *Halymenites major* Lesquereux which is supposed to be a fossil alga. F. H. Knowlton held that *Halymenites major* indicates marine conditions for wherever he had found it in association with invertebrates they were always of marine types. He also believed that it indicated relatively shallow water and near-shore conditions. These conclusions of Knowlton's are borne out fully by observations made in the Eocene of the Coastal Plain of Texas. However Lesquereux's supposition that these pipes are algal remains is not shared by the writer. These pipes are presumably bore holes made by marine animals.

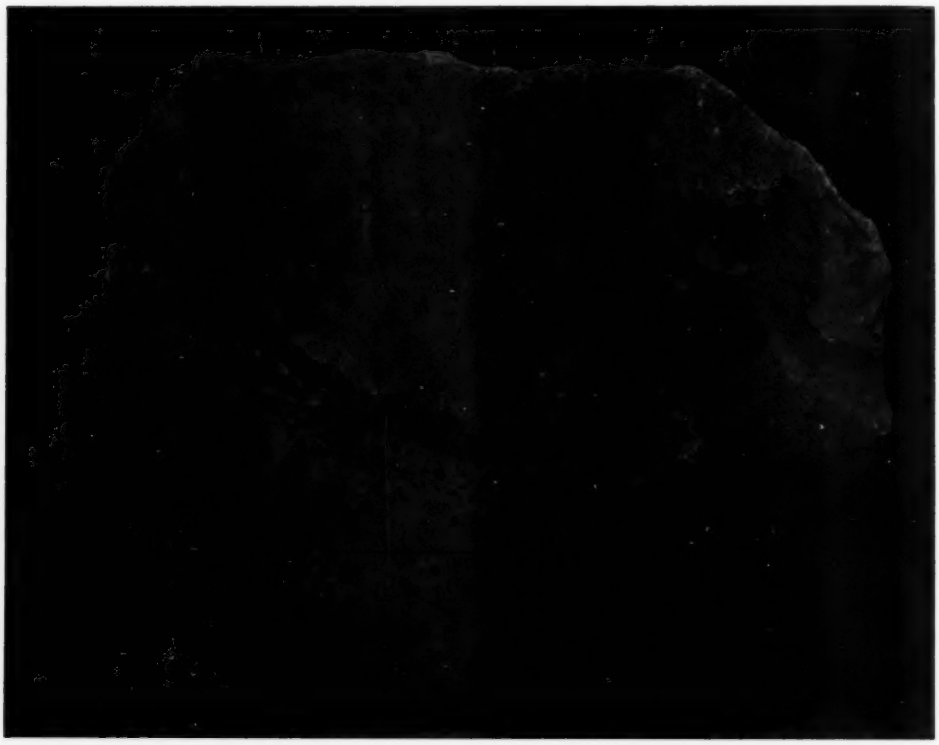

FIG. *1*—Photograph of interior of specimen of *Halymenites*, from the Salineno, basal Fayette sandstone, of Starr County, Texas.

In the Eocene sandstones of southwest Texas pipes of *Halymenites* occur as small as $\frac{1}{4}$ inch in diameter and as large as 2 inches in diameter and with correspondingly smaller or larger bumps. These pipes are often curved, may branch acutely, and occur parallel to, perpendicular to, and at angles to the bedding. Lengths up to 3 feet have been found with no change in diameter. As stated by Stenzel these pipes end bluntly with the bumps at the terminations of the pipes. The pipes when broken open, or when the interior is exposed by weathering, have a rough surface resembling the mold of a corncob. The filling of the pipes may be composed of material finer than, coarser than, or of the same texture as the enclosing rock. The parent rock is found to be arenaceous in every case, either sandstones, sandy shales, or sandy limestones. Thin sand beds are in many places honeycombed with "borings" of this fossil which terminate at any shale contacts above or below. The fact that they are associated in many cases with marine fossils leads to the conclusion that

they are unquestionably marine. *Halymenites* has been observed as low in the section as Taylor beds of Cretaceous age. The writer has found these fossils to be present in sandy phases of the Anacacho limestone of Uvalde County, Texas, and also in the younger Taylor-Navarro Eagle Pass beds of Maverick County, Texas, where their presence was previously noted by Udden.[3] W. T. Lee and Knowlton[4] report that *Halymenites* is very abundant in the Fox Hills sandstone and other upper Cretaceous formations of the Rocky Mountain region. Dane[5] finds this fossil abundantly represented in the Navarro beds of Arkansas.

In southwest Texas it has been found that *Halymenites* is more abundant in marine sandstones than sea shells, due perhaps to the fact that they are better preserved under surface weathering. In the area between Laredo and Rio Grande City this fossil is an invaluable aid in identifying thin marine sandstones interbedded with various types of marine and nonmarine beds. The writer is convinced that considerably more research is necessary to determine just how these pipes were made, but he is inclined to agree with Stenzel that they are borings of marine animals.

[3] Johan August Udden, A Sketch of the Geology of the Chisos Country, Brewster County, Texas Univ. Bull. No. 93, 1907, p. 44.

[4] Lee and Knowlton, U.S.G.S. Prof. Paper 101, 1917, p. 242.

[5] Carle H. Dane, Upper Cretaceous Formations of Southwest Arkansas, Ark. Geol. Survey, Bull. No. 1, 1929, pp. 124–125.

MANUSCRIPT RECEIVED BY THE EDITOR SEPTEMBER 25, 1941.

CORRECTION

DILOBELLA WISCONSINENSIS KAY, FOR D. SIMPLEX KAY

G. MARSHALL KAY
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That *Dilobella simplex* Kay (Jour. Paleontology, vol. 14, pp. 257–258, 1939) is a homonym of *D. simplex* (Krause) Bassler and Kellett (Geol. Soc. America, Spec. Paper 1, p. 287, 1934) has been reported to the author by A. F. Agnew of the Illinois Geological Survey. The new name *Dilobella wisconsinensis* Kay is proposed to replace *D. simplex* Kay, not (Krause).

JOURNAL OF PALEONTOLOGY, VOL. 16, NO. 2, PP. 274–283, MARCH 1942

REVIEWS

THE MAMMALIAN FAUNA OF THE WHITE RIVER OLIGOCENE, by William Berryman Scott and Glenn Lowell Jepson, *Transactions of the American Philosophical Society*, vol. XXVIII; Part IV, THE ARTIODACTYLA, by W. B. Scott and Part V, THE PERISSODACTYLA, by W. B. Scott, pp. 363–975, figs. 118–157, pls. 36–100: Issued April 1940 and June 1941: Complete volume, $10.00.

These are the last two parts of the monumental work undertaken by Scott and Jepson in 1934. The first three parts: Insectivora and Carnivora; Rodentia; and Lagamorpha have been issued separately and cover some 350 pages with extensive figures and plates on these groups. The two parts reviewed here are the largest of the volume and cover some 700 pages on these important orders of mammals. This is entirely the work of Dr. Scott and bears many evidences of his painstaking and thorough work.

Dr. Scott can certainly be called the dean of American vertebrate paleontologists. His wide acquaintance with the men of an earlier day in this field and his half century of distinguished service at Princeton make him eminently fitted to carry to completion the vast work projected only eight years ago.

It is now nearly one hundred years since the first notices of the mammalian fauna of the Dakota Bad Lands were published. Since that time no other North American fossil field has achieved greater recognition, nor has the amount and preservation of its material been equaled. The White River country is still a favored collecting ground of many institutions and individuals, but papers on its fauna have been less common in recent years.

Part IV, the Artiodactyla, covers nine generally recognized families, which Dr. Scott places in four suborders. Of this extensive primitive group only two families survive in the modern world.

The first suborder, Paleodonta, comprises two families, the Leptochoeridae and the Entelodontidae. The Leptochoeridae, known from incomplete material is a survivor from the Eocene and seems to be related to the European Dichobunidae. The real origin of the family is uncertain and it remains one of the least understood of the White River forms. The Entelodontidae is discussed at length in considerable detail since these animals are numerous and diversified in White River time. By and large they form a homogenous group with general agreement as to genera, etc. *Archaeotherium* of the Chadron and Brule, is replaced in the upper beds by *Pelonax*, *Megachoerus*, and *Scaphohyus* which seem to have been migrants from some other region. The Gobi fossils connect the European and American entelodonts, but are of no real taxonomic significance. Some six genera and fifteen species of the family are discussed in this section.

Under Matthew's old suborder Ancodonta is the single peculiar family Anthracotheriidae of Leidy. This is divided as usual into two subfamilies, Anthracotheriinae and Bothriodontinae. The first of these probably does not occur in North America although questionable and mistaken references to the subfamily have been made. The Bothriodontinae (new name), while not common fossils in the White River are represented by five genera. This material has been subject to much diversity of opinion, due in part to its fragmentary nature and also to the obscurity of its systematic position. Dr. Scott believes that the Old World origin of the subfamily is demonstrated by its sudden appearance, but that many of the later genera are probably of American origin.

The third suborder, Suina also contains but a single family the Tayassuidae which is in turn represented in the White River by the single genus *Perchoerus*. These animals are rare in collections which probably accounts for the few, only three, species that have been described. The origin of this genus is not definitely known but probabilities seem to favor its migration from the Old World.

Section B of this monograph is devoted to the Ruminata, made up entirely of the fourth suborder the Tylopoda, or the Camels and their much diversified allies. Dr. Scott

looks upon this group of animals as taking the place in North America which was filled by the Pecora or true ruminants in the Old World. The Tylopoda of Scott are derived from similar forms in the Uinta fauna where they form a more closely knit group. From this evidence, Scott surmises that the Tylopoda originated in the lower or middle Eocene and migrated, presumbly from Asia in the later Eocene. Four of the five families of this section are not found outside North America in post-Eocene time but the Camelids spread into the Old World in the Pliocene. The arrangement of families in this suborder is similar to that Scott originally suggested, but as he states "has not found general favour among paleontologists." The first of his three superfamilies the Hypertraguloidea contains the family (same name) and three subfamilies Hypertragulinae, Hypisodontinae and Leptomerycinae. In this same superfamily is placed the Protoceratidae, a grouping with which few would quarrel. In support of these relationships Dr. Scott cites the evidence of the Uinta forerunners of the Tylopoda which seem to be united more closely, as well as the evidence of the peculiar occlusion of the caniniform first lower premolar behind the upper canine tooth. Whatever this evidence later proves to be worth, Scott's views must not be idly dismissed, for few students have seen as much of the evidence as he has. In connection with his discussion of these subfamilies a description of the skeleton of *Hypertragulus* and *Hypisodus* covers many points for the first time.

Under the Protoceratidae, three genera are discussed: *Pseudoprotoceras*, *Calops* and *Protoceras*. The first of these is allied to, but not ancestral to *Protoceras*, and at present is not satisfactorily differentiated from *Calops*. *Calops* is known from Marsh's original material which is not shown to be completely distinct from *Protoceras*. The classic genus *Protoceras* is well summarized and an extended description of the skeleton is given.

The discussion of the Camelidae is limited to four genera. *Eotylopus* is regarded as a survival from the Eocene and unrelated to the other White River forms. *Pseudolabis* is not well enough known to draw any conclusions from. *Paratylopus* has certain characters in common with *Poebrotherium*, but its real relationships are not yet clear. *Poebrotherium* is by far the commonest of the White River camels and is known from complete material upon which three recognized species have been described. Although this genus is generally regarded as ancestral to many of the later members of the family, Dr. Scott is inclined to question this view on the grounds of certain points in the anatomy.

The last superfamily discussed is the Oreodontoidea which is made up of the two recognized families Agriochoeroidae and Merycoidodontoidea. The reviewer considers Dr. Scott's choice of the name Oreodontoidea as a happy one and with him hopes it will meet general acceptance. Everyone agrees that these families are a natural group even though they are distinctly separated in the White River. The merycoidodonts include at least six genera and the agriochoerids one or possibly two closely related ones. The pecularities of these animals are discussed in detail, as well as the older and more modern interruptions of their characters and probable systematic position. Some nineteen species of the first six genera are recognized and six under the family Agriochoeridae.

Part V of this great work was issued in June 1941, and is an extended discussion of the Perissodactyla by Dr. Scott. This great group made up of nine families of even-toed animals was once the dominant order in North America. By White River time the decline had already set in, one family had disappeared and another, the brontotheres, dropped out at the close of the Chadron. Even in individual members the Perissodactyla were exceeded by the Artioclactyla, a proportion which remained unbalanced from then on.

There is little disagreement among paleontologists as to the classification of the order Perissodactyla, but the group is an important one since it includes our most valuable time fossils, the horses. Scott divides the order into two suborders: the Chelopoda, or normal perissodactyls and the Ancylopoda or those with the hoofs converted into claws. Section A (Ceratomorpha) of his Chelopoda is made up of the superfamilies Tapiroidea and Rhinocerotoidea, the second being one of the most important White River groups.

The tapirs are represented by the single Old World genus *Protapirus*, a rare fossil form known from two skulls and a few skeletal elements. These apparently had no real proboscis, and were slender in body proportions. Three species have been described, the rarity of material, probably due to their habits, makes the genus one of the White River's "prize" fossils.

The superfamily Rhinocerotoidae contains four subdivisions which Scott recognizes as families. The first, Helaletidae is a survivor from the Eocene and may properly belong with the Tapiroidae. It is known from the single genus *Colodon* which is rare and based upon fragmentary material. Its true phylogenetic position must await the discovery of more complete material.

The other three subdivisions of the superfamily are all rhinoceros-like in character, form a fairly well defined group and are divided into two extinct and one surviving family.

The first and surviving family is the Rhinocerotidae represented in the White River by five genera. In his discussion of these genera, Professor Scott accepts and gives full credit to the conclusions of Dr. H. E. Wood who has long been a student of this group. The genus *Trigonias* is rare in the Big Bad Lands, most of our knowledge of it is based upon the fine series of skulls from Weld County, Colorado. It is the most primitive of all White River rhinoceroses, and retains several significant characters of the ancestral Eocene forms. In his discussion of the somewhat complicated "species" problem created by the Weld County skulls, Dr. Scott is inclined to agree with Dr. Matthew that there is but one or two species present. Nevertheless he lists and discussed the various species of the genus recognized by Wood. *Amphicaenopus* is a large animal typically from the upper Brule, but its validity is questionable until more material has been collected. *Caenopus* itself as restricted by Wood, is a small form, rare and imperfectly known. It is confined to the Chadron and upper Brule, but has not been found in the intervening beds. Two species of the genus are recognized. The ill-named genus *Subhyracodon*, with five species, may have been derived from *Trigonias*, since it is the characteristic genus of the later Brule. *Diceratherium* intergrades with *Subhyracodon*, the line between the two is an arbitrary one. The White River diceratheres are so near the former genus that they are difficult to characterize. One full species and two subspecies are recognized. The genus is best developed in the John Day and in the later Miocene, but in the upper Brule incipient nasal horns had appeared so the genus must be recognized here also.

The fourth family, Hyracodontidae, is probably a migrant from the Old World, since no suitable ancestral forms have been found in North America. It is a common form in the lower Brule but good specimens are scarce. Its narrow limits, taxonomic, geologic, and geographic, all point to its origin in some other region than the Great Plains. Scott recognized only one species. The Amynodontidae is represented in the White River by two species. That they were probably aquatic is generally agreed, but in many ways the significance of its peculiarities is not so obvious.

The second great section of this group is the Hippomorpha a name proposed by Wood. It is made up of the two families Brontotheriidae and Equidae. The first of these families was treated extensively by Osborn in his recent monograph of the group, which is followed in the main by Professor Scott's discussion. He does, however, dissent on several matters of taxonomy, his view is briefly: "Of course, Osborn never supposed that 37 species of the same family could possibly have co-existed at the same time and within the same narrowly limited region (Chadron). On the contrary he believed that these many species and genera were successive, not contemporary, and that a stratigraphic succession had been established. Further investigation has shown that . . . the supposed succession is largely illusory and that almost any type of skull, may occur at any level of the "Titanotherium Beds" or Chadron stage of the White River formation." Regarding the multitude of genera and species that have been described, Scott states, "how many did exist and what names should be given to them, are insoluble problems." A viewpoint with which the reviewer is in most hearty accord.

The Equidae of the White River are treated fully, under three genera and more

than twenty species. This was a time of rapid development of the horses, and whatever taxonomic rank is assigned them, they show great variation. The remains of horses are common in all three subdivisions of the White River, and each of the subdivisions has its own forms.

In closing his discussions of the horses Dr. Scott expresses an interesting view on the subject of irreversibility, with regard to minor structures. He feels that it may be possible that minor structures such as canine and incisor teeth might fluctuate in the course of the evolution of the group and not entirely follow Dollos law. This observation is made with special reference to the horses and camels.

The rare Chalicotheriidae is placed in a second suborder the Ancylopoda, an arrangement not in common usage. One species is recorded, described by Cope and further discussed by Lambe. The absence of remains of this group in the White River is thought to be due to the vagaries of collection and not to the actual geographical distribution of the animals.

In closing this monograph Dr. Scott discusses two of the less common fossils. First is *Epoicotherium*, discovered by E. Douglass, now referred to the Edentata, and second is the Marsupialia represented by the genera *Peratherium* and *Nanodelphys*. Other than the discussion by other authors, little is added to these two groups.

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THE ANATOMY OF THE PELECYPOD FAMILY ARCIDAE, by Harold Heath; *Transactions of the American Philosophical Society*, new series, vol. 31, pt. 5, pp. 287–319, 22 pls.

With the classification of the Arcidae founded upon the shell, and the greater part of the Recent species, to say nothing of the fossils, known only from the shell, this attempt to correlate gross features of the soft anatomy with the classification comes as a welcome contribution.

In justice to the author it must be said that he makes no claim to complete knowledge of the anatomy of any of the species studied, owing in some cases to the difficulties of dissection and in others to lack of adequate workable material. Nor does he propose any classification or even lay claim to the anatomy as an infallible guide to relationship. Instead, he appears to have encountered the same difficulties that beset every worker in systematics; that marked differences may occur in the same organ or organs among species that according to every other criterion are closely related, and conversely, the same organ or organs may differ but little among species not closely related or even among species of different genera.

The classification followed is that of Reinhart. In all, 34 species are treated under the following generic and subgeneric names:

Arca	7	species
Barbatia	2	"
Barbatia (*Cucullaerca*)	1	"
Barbatia (*Acar*)	3	"
Arcopis	2	"
Bathyarca	1	"
Trisidos	1	"
Anadara	2	"
Anadara (*Scapharca*)	4	"
Anadara (*Cunearca*)	3	"
Argina	1	"
Noetia	1	"
Cucullaea	1	"
Glycymeris	5	"

It would be unfair to criticize this paper from the standpoint of classification, since it is not a systematic paper and makes use of the above names merely for convenience. For the sake of those who might scan the paper for generic characteristics, however, it might be said that *Arca* as used here is known to many workers as *Navicula* (a recommendation for the acceptance of one or the other is now before the International Commission on Zoological Nomenclature); that *Acar* has little to do with *Barbatia* and should not be regarded as a subgenus of it; that neither species referred to *Acropsis* is a true *Acropsis;* that *Anadara* (the typical *Arca* of many workers) is not represented by typical species; that none of the species referred to *Scapharca* should properly be included in that subgenus; and that the species referred to *Noetia* is the type of *Eontia*, a genus distinct from but belonging to the same subfamily as *Noetia*.

An unfortunate feature of the paper, although one that is probably not easily rectified owing to the lack of material, is that in only about half of the genera and subgenera

is the genotype included among the species studied. This leads to the greatest misunderstanding with *Anadara*, and particularly the subgenus *Scapharca*. With *Cunearca* it is stated that of the three species studied, *C. incongrua* is doubtfully related to the others. The fact remains, however, that *C. incongrua* is the type of *Cunearca* and if any species is aberrant it is not that one. In the characters of the shell, *C. chemnitzi* and *C. perlabiata* are not very closely related to *C. incongrua*.

The main conclusions reached as to the taxonomic value of the various anatomical features are: The nervous and urogenital systems are little subject to change. The circulatory system is unreliable except for the pericardial cavity, which may be single, dorsally or ventrally septate, or completely divided into two chambers. The digestive system is highly plastic, and marked variation occurs within the same subgenus, although the shape of the stomach and position of the bile ducts and length of the intestine may be important. The abdominal sense organs and the number and arrangement of the muscles bridging the visceral cavity frequently are of use in determining whether nearly identical forms are to be regarded as one or different species.

Some discussion is given to dissimilarity encountered in two specimens, both identified as *Arca imbricata*, which, if both were normal, should not be included in the same genus. To anyone who has seen at first hand the anomalies encountered in a single class in mammalian anatomy, however, it would not be surprising to see even greater variation in molluscan anatomical details than in the relatively simple shell itself.

In résumé the author lists the main similarities or differences between the genera studied without making specific recommendations for changes in the classification, maintaining, as has been maintained before, that the best systematic arrangement should make use of all possible observable characters. The results are thus presented to the systematist to weave into the fabric as he sees fit.

The 22 plates adequately figure the details mentioned in the text.

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PALEOZOIC GASTROPOD GENOTYPES, by J. Brookes Knight, Geological Society of America, Special Paper No. 32, 510 pp., 96 plates, 1941.

Almost all serious paleontologists fall within one or the other of two great groups. One group, comprising stratigraphic paleontologists, consists of those who look upon paleontology principally as a means to an end or, more specifically, as a tool to aid in the solution of problems in stratigraphy and geologic history. They are the "practical" workers, primarily geologists, whose aims are concrete and objective realities, and they are chiefly concerned with the recognition, identification, and differentiation of closely related specimens or groups of specimens. They rarely have occasion to investigate relationships beyond the rank of genus. The other group is composed of those who view the study of fossils as an end in itself. They may be termed archeozoologists, and their interests are directed mainly toward fossils as animals, and the physical features of the geologic past concern them little except as those features affected the life of ancient times. Most of them are systematic paleontologists, whose ultimate objective is the classification of fossils, and because the species is the primary unit of taxonomy, individual specimens are of small importance to them except as representatives of particular species. Systematic paleontologists, starting with species, build genera and higher taxonomic groups to whatever limit may be set by their knowledge, experience, and good judgment.

The classification of fossils, or taxonomy, is a subjective science in that it is based upon ideas or concepts rather than upon facts. In this it is akin to philosophy, and our taxonomic colleagues may be termed the philosophers of paleontology. Like all philosophers, these paleontologists are largely concerned with the collation, evaluation, and systematization of the concepts of others. This is necessarily so because the philosopher's horizon in paleontology, as in any other field of learning or experience is too extensive for any individual to have personal knowledge of all its details. In the end, the success of any philosophy or taxonomic system may be measured by its ac-

ceptance, and this in turn depends upon the degree to which the knowledge, experience, and prejudices of many individuals accord with those parts of the system as a whole in which each believes that he is competent to judge.

Taxonomic groups superior to the genus exist outside of the binomial system of nomenclature and are so highly subjective that their names are not protected by the law of priority. They are, in effect, what any person wishes to regard and term them, and they need not be considered further here. Genera and species, however, are definite concepts identified by permanent names. They are definite concepts because each is dependent upon a type but each currently accepted concept is correct only insofar as it reflects the essential characters of its type. The concept of a particular genus or species may be different for each person who has studied it, but all are correct if this requirement is satisfied. A generic or specific concept may be strictly correct but at the same time superfluous and useless because it overlaps another previous similar concept too closely.

A genus is a concept of the second order because it is based fundamentally upon another concept, its type species. The first order specific concept, however, is based upon a concrete entity, the type specimen (or specimens). In final analysis, therefore, the concept of a genus comes to rest upon the proper understanding of the type specimen (or specimens) of its type species.

Every experienced paleontologist realizes that not uncommonly it is more difficult to determine the generic relationship of a species than it is to determine the specific identity of a specimen. This is so because few paleontologists can hope ever to be acquainted personally with the types, or other authentic specimens, of the type species of all the most prolific genera, not to mention the rarer ones. Consequently most of us accept the generic concepts of others and only raise an incredulous eyebrow in connection with a group in which we are particularly interested or when new and significant information comes to light in some more or less unexpected manner.

Few paleontologists have devoted themselves to the study of a particular group of fossils more exclusively and continuously than has Doctor Knight. Since the time, some 15 years ago, when he discovered a remarkably rich and well preserved assemblage of minute mollusks in shales of the St. Louis Pennsylvanian outlier, most of his investigations have been concentrated upon the gastropods. In an excellent series of papers that appeared from 1930 to 1934, he considered 9 families and about 36 genera of Paleozoic gastropods and described 126 species, mostly from the vicinity of St. Louis. In all this work unusual attention to taxonomy is evident. Knight was never satisfied to accept any taxonomic concept without first undertaking a thorough review of the evidence and reasoning upon which it was founded, and his own conclusions were based wherever possible upon the study of type specimens.

Such an objective or factual approach to the study of taxonomic problems has not been common because it is exceedingly difficult if not impossible for most workers to obtain access to all of the necessary type specimens. Knight appreciated these difficulties from personal experience and concluded that a comprehensive and unified study of type specimens would constitute a much more significant contribution to paleontologic knowledge than any comparable study of new material. In this he was undoubtedly correct.

The task Knight set himself, the examination and description of the genotype species of all Paleozoic gastropod genera, was a formidable one. No complete list of genera existed, and the type specimens of the genotype species (many not specifically designated) were distributed among an unknown number of museums in all parts of the world, over half of them in Europe. The successful completion of this work was made possible by the generous cooperation of many persons and a grant from the Penrose Fund of the Geological Society of America that allowed Knight to devote a year to European study. Above all, however, it is the result of Knight's painstaking efforts as a thorough bibliographer and keen observer. The published report is an invaluable addition to modern paleontologic literature, and in my opinion it is the most important volume yet to be issued by the Geological Society of

America. It is a standard reference work, the first of its kind and the foundation for future taxonomic studies, whose usefulness will continue undiminished until some other investigator, equally ambitious and competent, succeeds in completing a review of this same field. Because Knight's work is so well done, it is unlikely that any comparable review will be undertaken for many years to come.

Paleozoic Gastropod Genotypes is a study of species, not genera, and as such it is of much greater interest to specialists than to the more ordinary type of paleontologists. The latter, who are interested chiefly in determining to what genus a particular species should be referred rather than in investigating the characters of the genus itself, will find this work rather difficult to use and may be disappointed to learn that it will not automatically furnish them with answers to their problems. Clues are present in abundance but they must be tracked down by laborious and careful comparisons, and the final solution will depend upon each individual's judgment rather than upon authority. Knight's definite purpose was to make this volume a dictionary of facts concerning genotype species, and for the most part he has studiously refrained from expressing any opinions that are not compatible with this objective. It is difficult, however, to see how the inclusion of opinions regarding, for example, generic synonyms could detract in any way from the merits of the principle and more objective portion of the work, even though some of these opinions would sooner or later inevitably require emendation. After all, who could be better qualified to interpret this vast mass of factual information than Knight himself? Let us hope that he will soon publish a supplement setting forth his ideas regarding the interrelations of the genera.

Knight's work lists, in alphabetical order, 513 generic and subgeneric names proposed before 1938 and one proposed subsequently (*Lecanospira* and *Lepetopsis* are interchanged). Of these, 27 are suppressed as junior objective synonyms and 38 are invalid homonyms for which junior objective synonyms are available. One homonym, *Raphistoma*, is retained in good standing pending an appeal to the International Commission for a suspension of the Rules. Thirteen other invalid homonyms are based upon inadequately known species and all but one are referred to other genera as subjective synonyms. In 1938 Wenz proposed substitute names for two of these homonyms which, although now available, are listed only in footnotes. *Phymatopleura*, proposed by Girty in 1939 as substitute for an invalid homonym, is the only name published after 1937 that is listed in the text. Excluded from consideration are generic names commonly referred to the Hyolithidae, Tentaculitedae, Torellellidae, Conulariidae, and some others which Knight does not recognize as gastropods. *Pleurotomaria*, *Ptychomphalus*, and other similar gastropod genera, based upon post-Paleozoic species, are likewise excluded from consideration in this work.

The spelling of many generic names has been various emended by different authors. Such variants are mentioned by Knight in paragraphs of discussion but are not included among the 514 generic names. They are, however, listed in the index. Knight has rightly recognized the original spelling of all names except *Maclurites*, originally *Maclurite*, an obvious mechanical error.

Knight recognizes 436 generic names (including *Raphistoma*) as available. Some of these are useless because they are based upon unrecognizable species. Many more are probably subjective synonyms of each other (possess congeneric genotypes) but only 18 instances of equivalence are more or less obscurely indicated as follows:

Aulopea = *Distemnostoma*
Bathmopterus = *Euomphalopterus*
Geronticeras = *Platyceras*
Holopella = *Loxonema*
Microceras = *Cyrtolites*
Otospira = *Naticonema*
Palaeocapulus = *Orthonychia*
Palaeonustus = *Pseudotectus*
Platyostomella = *Naticopsis*
Protowarthia = *Sinuites*
Ptychonema = *Lophospira*
Rhabdospira = *Aclisina*
Rhabdostropha = *Loxonema*
Rhachopea = *Schizopea*
Saffordella = *Distemnostoma*
Sphaerodoma = *Strobeus*
Tomoceras = *Porcellia*
Tortilla = *Cirropsis*

The first described Paleozoic gastropod genus was *Bellerophon* Montfort 1808 from the European Devonian, and the first American genus was *Maclurites* LeSueur 1818 from the Ordovician. Until 1834 only two other Paleozoic genera had been proposed but by 1850, 42 names had been published and subsequently the total number has approximately doubled every 25 years. In all, 116 authors have contributed to the list of Paleozoic gastropod genera but half of all the names have been proposed by eight as follows: Cossmann, Donald-Longstaff, Hall, Knight, Koken, Koninck, Perner, and Ulrich and Scofield. Of these Perner was the most prolific, having published 17 per cent of the total (86, 76 of which are available).

The genotype species of the available genera may be classified geographically and geologically as follows:

	Camb.	*Ord.*	*Sil.*	*Dev.*	*L. Carb.*	*U. Carb.*	*Perm.*	*Total*
Europe	1	42	71	62	59	1	8	244
North America	14	70	7	28	8	36	2	165
Asia	2	2	1	0	0	3	11	19
Australia	0	0	3	3	0	0	1	7
South America	0	0	0	1	0	0	0	1
Total	17	114	82	94	67	40	22	436

For these genera, 180 genotypes were established by original designation, 130 by monotypy, 2 by tautonomy, and the remaining 123 by subsequent designation, many by Knight in previous publications. After his bibliographic studies, Knight's principal task involved location and study of the type specimens of these genotype species. He succeeded in locating and examining the types of 327 species, and an additional 63 species were described on the basis of other specimens believed to be authentic. No additional objective information was obtained for the remaining 46 species, less than 11 per cent of the total number.

Seven genera were originally named and described without having any named species assigned to them. Five have subsequently come into more or less use, and one has been suppressed as a junior objective synonym. The seventh, *Trochotremaria* Ryckholt, 1860, has never yet been associated with a named species and this is the only Paleozoic gastropod genus now without a genotype. Knight would apparently have designated a type for this genus had he known of any species meeting the requirements mentioned in the original description.

Knight has referred both generic and specific names to the authors who first published them, ignoring "courtesy" references to others from whose manuscripts the names may have been obtained, and in so doing acknowledges deviation from strict adherence to the Rules of Nomenclature. In adopting this practice, however, he is not as culpable as his remarks (p. 22) imply. The Rules state (Art. 21) that it must be clear in the original publication that the person to whom a name is referred by courtesy furnished "said name *and* its indication, definition, or description" (italics mine). In most instances it is certainly not clear that the author by courtesy furnished more than the name and the general concept for which this stands. Perhaps reasonable exceptions are names attributed to Ulrich in the report by Ulrich and Scofield and to Grabau in the paper by Sherzer and Grabau.

Danger is distinctly involved in the recogtion of courtesy references because the adopting author may not have applied the name as its originator intended, and confusion may arise in connection with the types. This confusion is not so serious with respect to genera because the genotype must be one of those species assigned to that genus in the first publication. More serious is the problem raised by courtesy references of specific names. If the reference is validly made in accordance with Article 21 of the Rules, the type or types must be among those studied by the courtesy author, but, if not, the type or types must be among those studied by the publishing author.

Of the 436 available generic names of Paleozoic gastropods, 35 were originally attributed by courtesy to another by the publishing author, 19 of them to Ulrich. The names of 82 genotype species are like-

wise attributed to others by the publishing authors, 64 to Barrande and 11 to Ulrich. Such courtesy references are indicated by Knight in footnotes.

Another fertile field for possible confusion exists in the publication of manuscript names in faunal lists. A new name so published without description or illustration is generally a *nomen nudum*, but if a new generic name is associated with the recognizable name of a previously published species, it may be construed that the generic name is thereby validated. Knight apparently believes that it is, but I doubt that the mere association of two names is to be strictly interpreted as "the citation or designation of a type species" (Art. 25a, Opin. 1B). If the new generic name were so associated with two recognizable specific names, a type would certainly not thereby be designated, and the fact that it is associated with only one establishes the genotype by monotypy rather than by "citation or designation."

Three generic names, *Chepultapecia*, *Gasconadia*, and *Lophonema*, first appeared in faunal lists and are referred by Knight to the authors in whose publications these lists were included. The last occurs in a list which, it is definitely stated, was contributed by Ulrich. Obviously Ulrich contributed not only the name but also whatever "indication" accompanies it, and if this name is to be recognized, it should be attributed to him. The other names likewise occur in a list contributed by Ulrich but no statement to this effect is made and there is nothing in the original publication to suggest this origin. These names if recognized, therefore, must be attributed to Weller and St. Clair in whose report they first appeared rather than to Ulrich, in spite of the facts that his faunal list was inserted in the manuscript by an editor subsequent to Weller's death and that St. Clair was not a paleontologist and knew nothing of these fossils.

For each genus Knight cites the original name of the species designated as genotype. Where objective synonyms exist, these are also cited if the original name is a junior synonym or a homonym. Subjective synonyms are not noticed except in a few of the paragraphs of discussion. In this connection it should be noted that the diplotype (type specimen upon which a genus ultimately rests) is not necessarily the same as the holotype of the type species. If the name of a designated type species is the subjective synonym (type is a different but conspecific specimen) of the name of an earlier described species, the type of the originally designated species (diplotype) is different from the holotype of the species as now recognized.

Authors have been even more negligent in the designation of type specimen of species than in the designation of type species of genera. Holotypes were originally designated for only 42 of the type species of 436 available genera. Monotypic holotypes exist in 59 other genera, and 28 other holotypes were established by subsequent designation before the appearance of Knight's work. In this, an additional 294 holotypes are designated and only 14 type species of Paleozoic gastropods now remain without holotypes. The types of these latter species are lost or were otherwise unavailable to Knight and they were not figured, or were figured very poorly, or the illustrations are believed to be composite or restored.

A careful study of Knight's discussions will provide anyone with a liberal education in the intricacies of zoologic nomenclature and should convince the most skeptical that stability can be attained only by strict application of the International Rules. For excellent examples of complexity, see *Bellerophon*, *Gonionema*, *Macrochilina*, and *Murchisonia*.

Knight's handling of nomenclatoral problems is uniformly skillful and his conclusions are logical. I question their legality in only one important respect. Two genera, *Hypseloconus* and *Praenatica*, had varieties originally designated as their types. Knight has raised these varieties to full specific rank and recognizes their validity as genotypes. Article 30 of the Rules gives directions for determining generic types. It does not actually state that a genotype must be a species but this is rather obviously implied and it is acknowledged by practically all paleontologists. Therefore it seems clear that a genotype must be a species (not a variety) mentioned in the first publication and the

later elevation of a variety to specific rank does not make that species eligible as a possible genotype.

Genotypes of all valid genera (except *Trochotremaria*) and of all but two of the genera whose subjective synonymity is suggested (because their names are invalid homonyms) are illustrated on the plates, some of them profusely. In addition, 31 line drawings, mostly sections, are included as text figures. The great majority of Knight's figures are original photographs of types and other authentic specimens and most of them are enlarged, up to a maximum of 30 times for a few of the smaller species. These are supplemented by copies of the original figures of the 46 species which he was unable to examine, and a few others.

Knight has long strongly opposed the publication of retouched photographs and none of the photographs on his plates has been retouched. This prejudice is natural in one whose viewpoint is so decidedly objective and who has been impressed so many times by inaccuracies introduced by unskillful retouching of photographs and idealization of drawings. However, it is practically impossible to so arrange the lighting of a specimen that all details photograph clearly, and in spite of the greatest care, some of Knight's figures are flat and unrevealing. These would undoubtedly have been much improved by the judicious use of a pencil and I, for one, would unquestioningly trust Knight's accuracy and good judgment in this matter.

The physical appearance of the report could have been improved somewhat by better pagination. Too many headings occur near the bottom of a page with text following on the next. Styling is not entirely consistent and there are also a number of minor typographical errors, including the curious omission of whole words. Few of the errors require notice, but the following corrections should be made:

On page 207—for *Nematrochus* Koken read *Nematotrochus* and for *Nematotrochus* Perner read *Nematrochus* (see pages 134–136).

On page 320, following *Sinuitopsis neglecta* Perner—for 1907 read 1903.

On page 467—for *Nematotrochus* read *Nematrochus*.

On page 501—for 1c read 1d, and for 1d read 1c.

J. Marvin Weller

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SOCIETY RECORDS AND ACTIVITIES

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The American Library Association created this last year the Committee on Aid to Libraries in War Areas, headed by John R. Russell, the Librarian of the University of Rochester. The Committee is faced with numerous serious problems and hopes that American scholars and scientists will be of considerable aid in the solution of one of these problems.

One of the most difficult tasks in library reconstruction after the first World War was that of completing foreign institutional sets of American scholarly, scientific, and technical periodicals. The attempt to avoid a duplication of that situation is now the concern of the Committee.

Many sets of journals will be broken by the financial inability of the institutions to renew subscriptions. As far as possible they will be completed from a stock of periodicals being purchased by the Committee. Many more will have been broken through mail difficulties and loss of shipments, while still other sets will have disappeared in the destruction of libraries. The size of the eventual demand is impossible to estimate, but requests received by the Committee already give evidence that it will be enormous.

With an imminent paper shortage attempts are being made to collect old periodicals for pulp. Fearing this possible reduction in the already limited supply of scholarly and scientific journals, the Committee hopes to enlist the cooperation of subscribers to this journal in preventing the sacrifice of this type of material to the pulp demand. It is scarcely necessary to mention the appreciation of foreign institutions and scholars for this activity.

Questions concerning the project or concerning the value of particular periodicals to the project should be directed to Wayne M. Hartwell, Executive Assistant to the Committee on Aid to Libraries in War Areas, Rush Rhees Library, University of Rochester, Rochester, New York.

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